

**A COMBINED LIMITED ENERGY STUDY OF  
ELECTRICAL ENERGY DEMAND AND USE AND HEATING SYSTEMS  
AT PINE BLUFF ARSENAL, ARKANSAS**

**VOLUME IV  
PROGRAMMING DOCUMENTATION**

**FINAL SUBMITTAL**

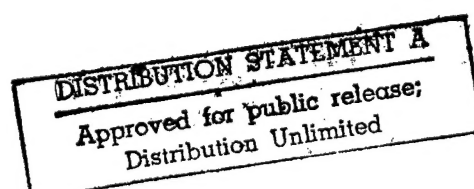
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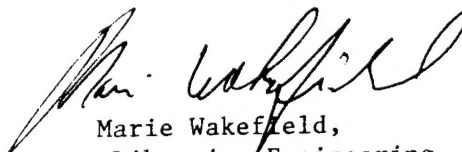


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## ENERGY PROJECT SUMMARY SHEET

<b>Installation and Location</b>	Pine Bluff Arsenal, Pine Bluff, Arkansas
<b>Project Title</b>	Repair Steam Pipe and Fittings
<b>Project Funding Category</b>	Federal Energy Management Program (FEMP)
<b>Total Investment</b>	\$78,000
<b>Annual Cost Savings</b>	\$472,100
<b>Savings-to-Invest. Ratio (SIR)</b>	112.6
<b>Simple Payback Period</b>	0.2 Years

### Contents

DD Form 1391, Front Sheet

Attachment 1 - Life Cycle Cost Analysis Summary

Attachment 2 - Description of Work to be Accomplished

Attachment 3 - Savings Calculations, Cost Estimate and Back-up Data

1. COMPONENT  <b>ARMY</b>	FY 19__ <b>MILITARY CONSTRUCTION PROJECT DATA</b>		2. DATE  September 6, 1996	
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas		4. PROJECT TITLE Repair Steam Pipe and Fittings - FEMP		
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST (\$000) \$78	
9. COST ESTIMATES				
ITEM	U/M	QUANTITY	UNIT COST	COST (\$000)
Repair/replace steam traps, piping, valves and fittings. Remove and dispose of asbestos insulation. Install new fiberglass insulation. See attached detailed estimate.				
Subtotal Construction Cost				\$63.2
Contingency (10%)				\$6.3
Total Construction Cost				\$69.5
Design Fee (6%)				\$4.2
SIOH (6%)				\$4.2
Total Cost				\$77.9
Total Requested (rounded)				\$78
10. DESCRIPTION OF PROPOSED CONSTRUCTION  The scope of work for this project consist of repairing and/or replacing all of the failed valves, fittings and steam traps on the existing steam distribution piping system served by the boilers in Buildings 32-060, 33-060 and 34-140. The work also includes asbestos abatement which will be required during removal of the existing fitting insulation. New fiberglass insulation will be installed to replace the removed asbestos.				

## ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 1**

**LIFE CYCLE COST ANALYSIS SUMMARY**

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: ECO-H1  
LCCID FY95 (92)

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: ECO-H1 IMPROVE STEAM DISTRIBUTION SYSTEM

FISCAL YEAR 1997 DISCRETE PORTION NAME: OPTION A - REPAIR EXISTING

ANALYSIS DATE: 07-01-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	\$	69572.		
B. SIOH	\$	4175.		
C. DESIGN COST	\$	4175.		
D. TOTAL COST (1A+1B+1C)	\$	77922.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT	\$		0.	
F. PUBLIC UTILITY COMPANY REBATE	\$		0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)	\$			77922.

2. ENERGY SAVINGS (+) / COST (-)

DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 16.79	0.	\$ 0.	15.08	\$ 0.
B. DIST	\$ .00	0.	\$ 0.	18.57	\$ 0.
C. RESID	\$ .00	0.	\$ 0.	21.02	\$ 0.
D. NAT G	\$ 2.81	168000.	\$ 472080.	18.58	\$ 8771246.
E. COAL	\$ .00	0.	\$ 0.	16.83	\$ 0.
F. PPG	\$ .00	0.	\$ 0.	17.38	\$ 0.
M. DEMAND SAVINGS			\$ 0.	14.88	\$ 0.
N. TOTAL		168000.	\$ 472080.		\$ 8771246.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	0.
(1) DISCOUNT FACTOR (TABLE A)		14.88	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	\$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)\$ 0.

4. FIRST YEAR DOLLAR SAVINGS  $2N3+3A+(3Bd1/(YRS \text{ ECONOMIC LIFE}))$ \$ 472080.

5. SIMPLE PAYBACK PERIOD (1G/4) .17 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) \$ 8771246.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 112.56  
(IF < 1 PROJECT DOES NOT QUALIFY)

A.5.H1-2

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 2**

**DESCRIPTION OF WORK TO BE ACCOMPLISHED**

## **ECO-H1**

### **Modifications and improvements to the steam distribution piping system.**

#### **Description**

This project consist of installing new steam distribution piping from the boilers in Buildings 32-060, 33-060 and 34-140 to the point of connection to all of the facilities currently served by the existing system. The work also includes asbestos abatement which will be required during removal of the existing pipe and fitting insulation.

A field survey was performed to identify all steam leaks from the steam piping located in production areas 31, 32, 33, and 34. The survey involved a visual inspection of all steam piping from the boilers to the entrance of the end use buildings. Observations during the field survey revealed many holes in the condensate return and compressed air distribution piping systems. However, all of the steam leaks found during the survey of the steam distribution system were associated with valves, fittings and steam traps. This indicates the steam distribution piping system has not failed and still has some useful life remaining.

The energy losses due to steam leaks within Production Areas 31, 32, 33 and 34 were estimated by performing a monthly natural gas balance for the entire Arsenal for calendar year 1995. This involved subtracting all identified steam consumption and steam losses from the total natural gas consumption for the Arsenal. Steam consumption at PBA includes process heating, process humidification and comfort heating. Steam losses include condensate leaks, thermal losses due to conduction and convection, system (boiler) efficiency and steam leaks.

A total of 104 steam leaks were identified along the steam distribution piping in Areas 31, 32, 33 and 34 and the heat trace piping for the white phosphorus area. The calculated losses due to steam leaks in these areas is about 14,000 MBtu per month. The total annual energy and cost savings achieved by eliminating the steam leaks is 168,000 MBtu and \$472,000, respectively.

The cost estimate for for this project assumes all 104 leaking valves, fittings and steam traps will be removed and replaced. An additional 24 leaks were assumed for the above ground tanks which were not operating during the survey. Some of the leaks can be eliminated by tightening or repairing the items, however, the cost estimate used replacement equipment to be conservative. The cost estimate also includes removal and disposal of the existing asbestos insulation and installation of new fiberglass insulation.

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 3**

**SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA**



## ECO-H1 CALCULATIONS

### ESTIMATE OF ENERGY LOSS FROM STEAM LEAKS

The energy losses due to steam leaks within Production Areas 31, 32, 33 and 34 were estimated by performing a monthly natural gas balance for the entire Arsenal for calendar year 1995. This involved subtracting all identified steam consumption and steam losses from the total natural gas consumption for the Arsenal. Steam consumption at PBA includes process heating, process humidification and comfort heating. Steam losses include condensate leaks, thermal losses due to conduction and convection, system (boiler) efficiency and steam leaks. The methods used for identifying and calculating the natural gas consumption for all of the identified users and losses are described in the following paragraphs.

All of the identified steam leaks are located in production areas 31, 32, 33, and 34. The steam system in area 44 is very small and any leaks associated with this system are negligible. The natural gas used in these areas is equal to the total natural gas energy supplied to the arsenal less the sum of the natural gas consumed by all other buildings within the Arsenal. The following equation was used to determine the natural gas consumption by the steam systems in Production Areas 31, 32, 33, 34, and 44:

$$\sum SS_P = NG_B - \sum IB_M \quad (1)$$

Where:  $\sum SS_P$  = The monthly natural gas consumption for the steam systems (production and distribution) in Areas 31, 32, 33, 34 and 44.  
 $NG_B$  = Total monthly facility natural gas consumption as shown on the monthly bills from the supplier.  
 $\sum IB_M$  = Sum of the monthly natural gas use for the 71 individual buildings with working natural gas meters.

The natural gas supply for PBA is provided through a single supply line and main meter. The monthly readings from the main meter are the basis for determining the total monthly natural gas consumption ( $NG_B$ ) at PBA and the monthly billing by the natural gas supplier. The natural gas is then distributed to approximately 75 buildings within the Arsenal. These facilities are equipped with plurality functioning gas flow meters that are read on the 25th of every month.

Ideally, the total natural gas consumption at PBA (as shown on the monthly bill) would be equal to the sum of the natural gas use for the 75 individually metered buildings. However, the meters for the boiler houses in Areas 32, 33, 34, & 44 have reportedly been broken for some time and no readings

are taken for these buildings. The natural gas consumption for all of the other 71 buildings with working meters (including the laundry and incinerator) was calculated from the meter readings. The natural gas consumption of these facilities was totaled on a monthly basis. These monthly totals are used as  $IB_M$  in the natural gas balance equations.

The natural gas consumed by the steam systems in the production areas is divided into three main groups: process steam use, comfort heating, and steam production and distribution system losses. This is described by the following equation.

$$\sum SS_P = PE_P + CH_P + SL_P \quad (2)$$

Where:

$PE_P$  = Process steam used for process heating and humidification.

$CH_P$  = Energy used for comfort (space) heating.

$SL_P$  = System losses from the steam production and distribution system.

Process steam energy is defined as steam heating or humidification utilized for the direct production of a product. The steam demand for process heating/humidification and for comfort heating for each building within the production areas is defined in Exhibit F of the Contingency Master Planning Program Steam and Compressed Air Utility Study prepared by CDG in October 1994 (CDG Utility Study). Steam demand values given in the CDG Utility Study were checked and updated by the Production staff. Total energy consumption for the steam systems in the production areas is therefore equal to the summation of the energy requirements for each area.

$$PE_P = PS_{31} + PS_{32} + PS_{33} + PS_{34} + PS_{44} \quad (3)$$

Where:

- $PS_{31}$  = Process steam consumption in production area 31.
- $PS_{32}$  = Process steam consumption in production area 32.
- $PS_{33}$  = Process steam consumption in production area 33.
- $PS_{34}$  = Process steam consumption in production area 34.
- $PS_{44}$  = Process steam consumption in production area 44.

System losses ( $SL_P$ ) from the steam production and distribution system include conversion losses from changing the chemical energy of the natural gas to steam energy (boiler efficiency), thermal losses due to convection and conduction from the distribution system piping, losses as a result of not returning the warm condensate, and losses due to steam leaks from the distribution system piping. The losses from the steam system are described by the following equation:

$$SL_P = CL_P + TL_P + LEAKS_P \quad (4)$$

Where:

$CL_P$  = Energy losses from condensate system leaks.

$TL_P$  = Thermal energy losses through the pipe insulation.

$LEAKS_P$  = Leaks from the steam distribution system.

Boiler efficiency measurements and calculations indicated that the 70 percent efficiency used by the PBA staff was a fairly accurate average. The conversion efficiency losses are taken into account by dividing all of the calculated steam consumption values (in MBtu of steam) for areas 31, 32, 33 and 34 by 0.7 to obtain MBtu of natural gas. The calculated steam consumption values (in MBtu of steam) for area 44 were divided by 0.8 to obtain MBtu of natural gas. Since boiler efficiency is accounted for in the calculations for all of the steam consumption values listed in Equations 1 through 4, a separate term for conversion losses was not included in the system losses equation.

The condensate return system at PBA is in very poor condition and is scheduled for replacement in the near future. Calculations of the natural gas energy losses due to the poor condition of the condensate system assumed approximately 10 percent of the available condensate is currently being returned, the condensate temperature is 120 degrees F and the make-up water temperature is about 68 degrees F.

Thermal losses ( $TL_P$ ) from the steam supply piping to the atmosphere due to conduction and convection were calculated for each month of the year. The amount of these losses is influenced by the temperature of the pipe and the outside air temperature. Thirty year averages were used for monthly temperatures in these calculations.

By combining equations 1, 2 and 4, and rearranging, the following expression was derived for calculating natural gas use due to steam leaks in the production areas:

$$LEAKS_P = NG_B - IB_M - PE_P - CH_P - CL_P - TL_P \quad (5)$$

Table 3.2-1 PBA Natural Gas Balance for 1995												
Natural Gas Component	Estimated Monthly Natural Gas Consumption (MBtu)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Natural Gas Bills ( $NG_B$ )	72,425	65,166	58,220	47,855	37,697	38,392	37,838	34,199	35,284	41,937	58,597	77,672
2. Bldgs w/ Meters ( $IB_M$ )	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,079	6,715	9,367
3. Process Heat ( $PE_P$ )	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544
4. Comfort Heat ( $CH_P$ )	35,117	27,788	20,787	6,854	2,517	271	73	137	1,322	7,812	18,317	30,387
5. Condensate Loss ( $CL_P$ )	4,228	3,669	3,382	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567
6. Conduction Loss ( $TL_P$ )	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530
7. Steam Leaks ( $LEAKS_P$ )	9,148	8,700	9,849	18,005	15,277	16,257	14,024	12,505	13,417	11,234	15,977	18,278
Steam Leaks (7) = (1) - (2) - (3) - (4) - (5) - (6)												

The first line of Table 3.2-1 lists the natural gas consumption for the entire Arsenal for each month of 1995. The second line shows the monthly consumption of all buildings within the Arsenal that have working natural gas meters. Line three of Table 3.2-1 lists the calculated natural gas use for process heating and humidification in areas 31, 32, 33, 34 and 44. The estimated natural gas consumption for space (comfort) heating is listed in line four. The monthly estimates of additional natural gas consumption required due to the poor condition of the condensate return system are shown in line five. Line six shows the estimated energy required to overcome the thermal losses through the steam supply pipe insulation. The estimated natural gas consumption that is wasted due to steam leaks is tabulated in line seven.

The estimated losses due to steam leaks are lower during the winter months of January, February and March. Regardless of how and where the steam leaks occur, the driving force for steam leaks is the system operating pressure. Since the boilers and distribution system pressure are kept fairly constant throughout the year, the steam leaks should also remain constant throughout the year. This indicates the actual winter conditions during 1995 were probably milder than the average bin data that was used to calculate the energy use for space heating. Therefore, if the calculated energy use for space heating was decreased to match the actual 1995 energy consumption for space heating, the estimated steam leaks would increase during these winter months.

The estimated energy use for comfort heating during the summer months is negligible. Therefore, the steam leak estimates for these months should more accurately reflect the average value of the actual steam leaks. The average estimated loss due to steam leaks during June, July and August is 14,260 MBtu per month. Based on this value, the economic analyses assume that the steam leaks remain constant at 14,000 MBtu per month throughout the year. Therefore, the total annual estimated energy loss due to steam leaks at the Arsenal is about 168,000 MBtu per year. Using \$2.81 per MBtu as the average cost of natural gas, the cost of steam leaks at PBA is approximately \$472,000 per year.

To ensure that all of the natural gas consumed at PBA was accounted for, an additional calculation was performed using the consumption data from the boiler logs. The PBA staff estimates the monthly natural gas use for the boiler houses by taking the steam totalizer readings and dividing that value by an assumed boiler efficiency of 70 percent. Our boiler efficiency measurements and calculations indicate the boilers in areas 32, 33 and 34 operate at an average efficiency of about 70 percent and the boiler in area 44 operates at an efficiency of about 80 percent.

The total natural gas consumption at PBA should equal the estimated natural gas use for the boilers in areas 32, 33 and 34 plus the total natural gas use for the 71 metered buildings plus the calculated natural gas use for the boiler in area 44. The estimated natural gas use is a little higher than the actual for the first three months and lower than the actual for the remainder of the year. The annual total of the estimated natural gas use is within about five percent of the actual natural gas use.

PBA Natural Gas Balance														
Nat. Gas Bal. (MBtu/Mo)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total MBtu/yr	Total Cost
Natural Gas Bills (1)	72,425	65,106	68,220	47,855	37,697	38,392	37,838	34,189	35,284	41,937	58,597	77,672	605,282	\$1,700,842
Buildings w/ Meters (2)	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,078	6,715	9,367	75,872	\$213,200
Process Heat (3)	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849	\$364,875
Condensate Losses (4)	4,228	3,669	3,392	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567	35,395	\$99,460
Conduction Losses (5)	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530	50,114	\$140,821
Comfort Heating (6)	35,117	27,788	20,787	6,854	2,517	271	73	137	1,322	7,812	18,317	30,387	151,382	\$425,382
Steam Leaks (7)	9,148	8,700	9,849	18,005	16,277	16,257	14,024	12,505	13,417	11,234	15,977	18,278	192,671	\$457,105
														\$1,700,842
(1) Monthly natural gas bills for entire Arsenal from Felling Tree Enterprises.														
(2) Monthly totals from the 71 metered buildings at PBA, see attached table.														
(3) See Process Energy Use Calculations.														
(4) Assumed: 10% of condensate is returned, TC = 120 °F TGW = 68 °F Boiler eff = 70%														
(5) See Conduction Loss Calculations.														
(6) See Comfort Heating Calculations - Bin Temperature Method.														
(7) Steam leaks (7) = [(1) - (2) - (3) - (4) - (5) - (6)]														
PBA Natural Gas Balance - Corrected														
Corr. N.G. Bal. (MBtu/Mo)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total MBtu/yr	Total \$
Natural Gas Bills	72,425	65,106	68,220	47,855	37,697	38,392	37,838	34,189	35,284	41,937	58,597	77,672	605,282	\$1,700,842
Bldgs w/ Meters	9,187	10,282	7,633	5,274	2,505	3,814	5,233	5,277	4,505	6,078	6,715	9,367	75,872	\$213,200
Process Heat	10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849	\$364,875
Condensate Losses	4,228	3,669	3,392	2,847	2,353	2,312	2,180	1,934	2,058	2,397	3,469	4,567	35,395	\$99,460
Conduction Losses	4,564	4,080	4,392	4,116	4,138	3,890	3,971	3,984	3,947	4,234	4,266	4,530	50,114	\$140,821
Comfort Heating (8)	32,853	24,499	20,202	12,196	2,517	271	73	137	394	5,473	21,487	37,920	158,031	\$444,067
Steam Leaks	11,412	11,989	10,434	12,662	15,277	16,257	14,024	12,505	14,346	13,572	12,787	10,745	156,021	\$438,420
														\$1,700,842
Comfort Heating Correction Calculations (actual weather was not the same as the bin data)														
Space Heat w/ Summer = 0 (8)	32,853	24,499	20,202	12,196	4,807	4,193	2,220	(1,463)	394	5,473	21,497	37,920		
Calculated Corr. Values (10)	2,264	3,289	585	(5,342)	(2,290)	(3,922)	(2,147)	1,600	928	2,339	(3,180)	(7,533)		
Comfort Heat Corr. Values (11)	2,264	3,289	585	(5,342)	0	0	0	0	928	2,339	(3,180)	(7,533)		
(8) Calculated Comfort Heating (8) - Comfort Heat Corr. Value (11)														
(9) Current Month Nat. Gas Use (1) - Aug Nat. Gas Use (1) - (Current metered bldgs use (2) - Jun metered bldgs use (2))														
(10) Calculated Comfort Heating (8) - Space Heat w/ Summer = 0 (9)														
(11) Values from item (10) for heating months only.														

**PINE BLUFF ARSENAL**  
1995 Monthly Gas Meter Readings

GROUP 1 BUILDINGS																
Bldg. No.	32100	32101	32102	32103	32104	32105	32106	32107	32108	32109	32110	32111	32112	32113	32114	32115
Bldg. Name	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jan-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Feb-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Mar-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Apr-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-May-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jun-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jul-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Aug-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Sep-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Oct-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Nov-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Dec-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500

GROUP 2 BUILDINGS																
Bldg. No.	32116	32117	32118	32119	32120	32121	32122	32123	32124	32125	32126	32127	32128	32129	32130	32131
Bldg. Name	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jan-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Feb-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Mar-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Apr-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-May-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jun-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jul-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Aug-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Sep-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Oct-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Nov-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Dec-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500

GROUP 3 BUILDINGS																
Bldg. No.	32132	32133	32134	32135	32136	32137	32138	32139	32140	32141	32142	32143	32144	32145	32146	32147
Bldg. Name	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jan-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Feb-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Mar-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Apr-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-May-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jun-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jul-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Aug-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Sep-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Oct-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Nov-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Dec-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500

TOTALS																
Bldg. No.	32100	32101	32102	32103	32104	32105	32106	32107	32108	32109	32110	32111	32112	32113	32114	32115
Bldg. Name	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jan-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Feb-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Mar-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Apr-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-May-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jun-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Jul-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Aug-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Sep-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Oct-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Nov-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500
23-Dec-83	224	200	178	27	281	16	1	516	178	62	10	28	79	20	37	500

Process Energy Use Calculations														
Steam		N. Gas												
lbs/hr		MBtu/hr												
(1)		(2)		NOTES:										
Process Area 31 (3)		375 0.54		(1) From 1994 CDG Utility Study updated by PBA Production staff.										
Process Area 32 (3)		637 0.91		(2) Assumes 1000 Btu/lb of steam, boiler efficiency = 70% for areas 32, 33 & 34 and 80% for area 44.										
Process Area 33 (3)		75 0.11		(3) Assumes the production operating level is: 50% of maximum capacity.										
Area 34 Operational (4)		21158 30.23		(4) Assumes WP production operating level is: 50% of maximum capacity.										
Area 34 Stand By (5)		8463 12.09		(5) Assumes WP stand-by energy use level is: 40% of maximum capacity.										
Process Area 44		33 0.04		(6) From The Weather Almanac, Fourth Edition, 30 year average monthly temperatures.										
Totals		30,741 43.91		(7) From WP Production Schedule dated March 6, 1996.										
				(8) N. Gas MBtu/hr x Oper. Hrs/Mo + Stand-by N. Gas x (Total Hours/Month - Oper. Hrs/Mo)										
				(9) N. Gas MBtu/hr x Total Hours/Month										
Operating and Weather Data														
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Average OA Temp. (6)		41.4	44.6	53	62.4	70.2	78.2	81.5	80.6	74.2	63.7	51.9	43.7	
Days per month		31	28	31	30	31	30	31	31	30	31	30	31	365
Total Hours/Month		744	672	744	720	744	720	744	744	720	744	720	744	8760
Area 34 Op. Hrs/Mo (7)		0	80	110	50	40	110	120	10	10	0	0	20	550
Process Energy (MBtu/Mo)														
Area 34 (8)		8995	9576	10990	9812	8721	10700	11172	9177	8887	8995	8705	9358	115,887
Area 31 (9)		399	360	399	386	399	386	399	399	386	399	386	399	4,693
Area 32 (9)		677	611	677	655	677	655	677	677	655	677	655	677	7,969
Area 33 (9)		80	72	80	77	80	77	80	80	77	80	77	80	939
Area 44 (9)		31	28	31	30	31	30	31	31	30	31	30	31	361
Total Process Heating		10,181	10,647	12,176	10,759	10,907	11,848	12,357	10,362	10,034	10,181	9,853	10,544	129,849

A.5.HI-11



EXHIBIT F  
STEAM DEMAND FOR MOBILIZATION CONDITION

EQUIPMENT EFFECTIVENESS FACTOR %

PINE BLUFF ARSENAL, ARKANSAS  
DEPARTMENT OF THE ARMY

STEAM DEMANDS

BUILDING NUMBER	BLDG USE	VENTILATION CFM	HEATING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
31080	ELECTRONIC CALIBRATION FACILITY		349.99		349.99		349.99		349.99
31100	MAINT FACILITY		1,730.12		1,730.12		1,730.12		1,730.12
31150	PRODUCTION OFFICE		248.92		248.92		248.92		248.92
31310	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31330	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31420	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31440	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
31520	MIX BUILDING	15,290	2,005.00		2,005.00		2,005.00		2,005.00
31530	FILL AND PRESS	29,010	3,728.00	750	4,478.00	1500	5,228.00	1500	5,228.00
31531	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
31540	DOWNLOAD FACILITY		947.03		947.03		947.03		947.03
31570	MUNITIONS STORAGE		1,187.97		1,187.97		1,187.97		1,187.97
31620	PYRO MIX BLDG (THERMATE MIX)	14,860	1,969.00	20	1,969.00	20	1,969.00	20	1,969.00
31630	FILL AND PRESS	10,000	3,152.19	300	3,152.19	0	3,152.19	500	3,352.19
31631	BREAK AND RESTROOMS		239.26		239.26		239.26		239.26
31640	ASSEMBLY		947.03		947.03		947.03		947.03
31670	STORAGE		1,187.97		1,187.97		1,187.97		1,187.97
31720	PYROTECHNIC PRODUCTION	2,870	554.00	100	554.00	100	554.00	100	554.00
31730	STORAGE		149.86		149.86		149.86		149.86
31820	STORAGE		301.43		301.43		301.43		301.43
31830	AMMO QUAL FAC		149.86		149.86		149.86		149.86
31860	STORAGE		159.50		159.50		159.50		159.50
			20,919	750	27,344.42	1,620.00	27,794.42	2,120.00	28,294.42
32000	CAFETERIA		512.16		512.16		512.16		512.16
32030	INSPECTION GARAGE		706.04		706.04		706.04		706.04
32035	ORDNANCE SHOP		0.00		0.00		0.00		0.00
32070	IMPREG AND LAUNDRY		1,909.25	93	2,002.25	93	2,002.25	93	2,002.25
32080	MHE BATTERY SHOP		349.99		349.99		349.99		349.99
32090	WAREHOUSE		855.31		855.31		855.31		855.31
32100	ELECTRONIC CALIBRATION FACILITY		1,730.12		1,730.12		1,730.12		1,730.12
32130	AMMO QUAL FAC		561.96		561.96		561.96		561.96
32150	AMMO QUAL FAC		248.92		248.92		248.92		248.92
32230	FILTER BLDG		1,628.91		1,628.91		1,628.91		1,628.91
32270	WAREHOUSE		1,628.91	0	1,628.91	0	1,628.91	0	1,628.91
32310	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32330	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32420	RAW MAT. WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32440	EQUIPEMENT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
32510	PROD ENGR LAB		518.13		518.13		518.13		518.13
32520	PROD ENGR LAB		1,067.96		1,067.96		1,067.96		1,067.96
32530	FORMER B2 FACILITY		2,543.52		2,543.52		2,543.52		2,543.52
32531			151.46		151.46		151.46		151.46

# EXHIBIT F STEAM DEMAND FOR MOBILIZATION CONDITION

CDG UTILITY STUDY

## EQUIPMENT EFFECTIVENESS FACTOR %

## STEAM DEMANDS

### PINE BLUFF ARSENAL, ARKANSAS DEPARTMENT OF THE ARMY

BUILDING NUMBER	BLDG USE	VENTILATION CFM	HEATING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
32540	FORMER BZ FACILITY		947.03		947.03		947.03		947.03
32550	AMMO QUAL FAC		353.92		353.92		353.92		353.92
32570	OPERATIONS GENERAL PURPOSE		1,209.30		1,209.30		1,209.30		1,209.30
32610	DRYING	14,900	1,712.26	7.26	1,712.26	7.26	1,712.26	7.26	1,712.26
32620	COLORLED SMOKE MIX (GLATT)	15,290	2,005.00	436	2,441.00	872	2,877.00	872	2,877.00
32630	STORAGE		1,673.76		1,673.76		1,673.76		1,673.76
32631	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
32640	PYROTECHNIC PRODUCTION		2,206.10		2,206.10		2,206.10		2,206.10
32670	SUL-7 TEST	12,510	1,187.97	100	1,187.97		1,187.97		1,187.97
32720	PROD ENGR LAB		418.58		418.58		418.58		418.58
32730	PROD ENGR LAB		173.74		173.74		173.74		173.74
32820	MATERIAL STORAGE		301.43		301.43		301.43		301.43
32830	MATERIAL STORAGE		149.86		149.86		149.86		149.86
32860	STORAGE		159.50		159.50		159.50		159.50
			34,491.10	63.6	35,027.36	972.26	35,463.36	972.26	35,463.36
33080	SAFETY EQUIP		349.99		349.99		349.99		349.99
33100	CHANGE HOUSE		1,730.12		1,730.12		1,730.12		1,730.12
33150	PRODUCTION		248.92		248.92		248.92		248.92
33310	RAW MAT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33330	RAW MAT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33420	RAW MAT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33440	RAW MAT WAREHOUSE		1,837.00		1,837.00		1,837.00		1,837.00
33520	MIX BUILDING	16,610	1,944.00		1,944.00		1,944.00		1,944.00
33530	FILL AND PRESS	26,900	4,725.86	50	4,725.86	50	4,725.86	50	4,725.86
33531	PUBLIC TOILET		239.26		239.26		239.26		239.26
33540	STORAGE		948.37		948.37		948.37		948.37
33550	IN PROCESS STORAGE		388.02		388.02		388.02		388.02
33570	LAP		1,187.97		1,187.97		1,187.97		1,187.97
33620	STARTER MIX BUILDING		1,067.96		1,067.96		1,067.96		1,067.96
33630	FILL AND PRESS	10,000	2,420.61	100	2,420.61	100	2,420.61	100	2,420.61
33631	OFFICE AND RESTROOMS		239.26		239.26		239.26		239.26
33640	ASSEMBLY BUILDING		947.03		947.03		947.03		947.03
33650	IN PROCESS STORAGE		353.92		353.92		353.92		353.92
33670	M116 LAP		1,187.97		1,187.97		1,187.97		1,187.97
33720	KC103 PROP		301.43		301.43		301.43		301.43
33730	QC TEST FAC		149.86		149.86		149.86		149.86
33820	STARTER MIX SLUGS		301.43		301.43		301.43		301.43
33830	COMPONENT STORAGE		149.86		149.86		149.86		149.86
33860	STORAGE (GLOO)		159.50		159.50		159.50		159.50
			2,379.9	150	26,489.36	450.00	26,789.36	450.00	26,789.36

A-5.HI-13

EXHIBIT F  
STEAM DEMAND FOR MOBILIZATION CONDITION

QUIPMENT EFFECTIVENESS FACTOR %

INE BLUFF ARSENAL, ARKANSAS  
DEPARTMENT OF THE ARMY

## STEAM DEMANDS

BUILDING NUMBER	BLDG USE	VENTILATION CFM	HEATING LOAD LBS STEAM/HR	CURRENT DEMAND STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	PARTIAL BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR	BASELINE EMERGENCY STEAM PROCESS LOAD LBS STEAM/HR	TOTAL LOAD LBS STEAM/HR
1110	WP FILLING	139,310	16,957.00	10602.42	27,559.42	14136.56	31,093.56	14136.56	31,093.56
1120	AMMO QUAL FAC		1,221.45		1,221.45		1,221.45		1,221.45
1130	WP UNLOAD TANKS		474.95	7555.06	8,030.01	7555.06	8,030.01	7555.06	8,030.01
1170	WP BULK STORAGE			21659.27	21,659.27	21659.27	21,659.27	21659.27	21,659.27
4350	ASSEMBLY AND PACKOUT		879.89		879.89		879.89		879.89
4370			331.19		331.19		331.19		331.19
4420			319.82		319.82		319.82		319.82
4430			1,861.28		1,861.28		1,861.28		1,861.28
4620	RAW MATERIAL WAREHOUSE		1,768.37		1,768.37		1,768.37		1,768.37
4630	PYROTECHNIC PRODUCTION	8,000	2,270.12	1200	3,470.12	1200	3,470.12	1200	3,470.12
4640	HC MIX	57,820	5,761.00	(1200)	5,761.00		5,761.00		5,761.00
4650	START MIX SLEEVE		1,369.83	(100)	1,369.83		1,369.83		1,369.83
4660	SUB ASSEMBLY		326.47		326.47		326.47		326.47
4820	STORAGE		159.50		159.50		159.50		159.50
34910	FE MAINTENANCE SHOP		9,632.65		9,632.65		9,632.65		9,632.65
14970	ADMIN BUILDING		451.97		451.97		451.97		451.97
			43,785.48	4,231.7	84,802.23	44,550.89	88,336.37	44,550.89	88,336.37
12960	GRENADE TEST BUILDING		421.00		421.00		421.00		421.00
14110	LAP		3,957.49	33	3,990.49	33	3,990.49	33	3,990.49
			135,168.85	42,906.01	178,074.86	47,626.15	182,795.00	48,126.15	183,295.00

127493 43886

A.5.HI-14



SUBJECT WP Energy Use  
DESIGNER W. Todd  
CHECKER \_\_\_\_\_

AEP NO 694 1331 004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 6-12-96  
DATE \_\_\_\_\_

Estimate Steam Demand for WP Area:

<u>Bldg. No.</u>	<u>Building Name</u>	<u>Max. <sup>lb</sup>/hr</u>	<u>Oper. <sup>lb</sup>/hr</u>	<u>Std. by <sup>lb</sup>/hr</u>
34110	WP Filling	10600 (1)	10600 (2)	8480 (5)
34130	WP Unload Tanks	7550	750 (3)	- 0 - (6)
34170	WP Bulk Storage	21660	6500 (4)	6500 (4)
34630	Pyrotechnic Prod.	1200	1200 (2)	- 0 - (6)
34640	HC Mix	1200	1200 (2)	- 0 - (6)
34650	Start Mix Sleeve	100	100 (2)	- 0 - (6)
Totals		42310	20350	14980

$$\text{Oper. \%} = \frac{20350}{42310} = 48.1 \% \Rightarrow \text{say } 50 \%$$

$$\text{Stand by \%} = \frac{14980}{42310} = 35.4 \% \Rightarrow \text{say } 40 \%$$

- (1) From CDG Utility Study see attached copies.
- (2) Assume these operations are at or near 100% utilized.
- (3) Assume this is a batch process operating 10% of the time.
- (4) Assume after WP is at its production temperature, that 30% of energy is required to maintain the temperature (overcome the thermal losses)
- (5) Assume 80% of energy is used during stand-by. See attached telephone call confirmation with E&T staff.
- (6) Assume these operations are shut down during stand-by.

**Telephone Call Confirmation**

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**Date:** June 12, 1996**Project Number:** 694-1331-004**Project Name:** PBA Electric and Heating Study**Received:****Placed:**

by W. Todd

**Local:****Long Dist.:**

501-540-2918

**Conversed with:** Pat Lawrence**of**

Pine Bluff Arsenal E&amp;T Division

**Regarding:** Steam energy consumption for the WP area.

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During the last five years the WP production building has been operating one line out of the four available lines (two wet fill and two dry fill).

**During Production:**

- Dry fill lines use more energy than wet fill lines.
- One-half of the leak test ovens are on only during the shift.
- WP transport pipes are kept hot.

**During Stand-by (nights and weekends):**

- Dry fill and wet fill cabinets kept hot.
- All of the leak test ovens are off.
- WP transport pipes are kept hot.

**During Extended Stand-by (when no production for about one month):**

- Almost everything will be turned off.

**Distribution:** PBA File**By**William T. Todd, PE

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A.5.H1-16

## WP Production Schedule

	No. Shifts Per Month	Hrs Worked Per Shift	Hrs Worked Per Month
Feb 95	8	10	80
Mar 95	11	10	110
Apr 95	5	10	50
May 95	4	10	40
Jun 95	11	10	110
Jul 95	12	10	120
Aug 95	1	10	10
Sep 95	1	10	10
Oct 95	0	0	0
Nov 95	0	0	0
Dec 95	2	10	20
Jan 96	0	0	0
Feb 96	0	0	0

550

TOTAL HRS WORKED: 550

NOTE: Each shift consists of 10 hrs, 0630 - 1700 hrs,  
four days/week.

Comfort Heating Calculations - Bin Temperature Method													
Design IAT =		70	°F	(1)		From ASHRAE Handbook, 1981 Fundamentals.							
Balance Temp =		65	°F	(2)		From CDG Utility Study updated by PBA Production staff. Steam demand reduced by 30% for CDG's assumed losses & by (Bal T-Des OAT)/(Des IAT - O°), boiler eff = 70%.							
Design OAT (1) =		16	°F	(3)		Bin temperature data from Engineering Weather Data, TM 5-785.							
Heating Load (2) =		89.2	MBtu/Hr	(4)		Percent Load = (Balance Temp - OA Temp) / (Balance Temp - Design OAT)							
				(5)		MBtu = Heating Load x Percent Load x Hours							
OA Temp	% Load	Jan		Feb		Mar		Apr		May		Jun	
(3)	(4)	Hours (3)	MBtu (5)	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu
62	6%	36	197	32	175	77	421	127	694	95	519	24	131
57	16%	44	641	49	714	92	1340	105	1530	55	801	8	117
52	27%	54	1279	71	1681	103	2438	83	1955	29	687	1	24
47	37%	81	2655	96	3147	115	3770	43	1410	13	426		0
42	47%	103	4315	117	4901	112	4692	21	880	2	84		0
37	57%	108	5508	102	5202	75	3825	5	255		0		0
32	67%	122	7333	91	5468	44	2645	2	120		0		0
27	78%	84	5814	60	4153	17	1177		0		0		0
22	88%	48	3759	21	1645	5	392		0		0		0
17	98%	23	2011	7	612	1	87		0		0		0
12	100%	11	982	1	88	0	0		0		0		0
7	100%	5	446	0	0	0	0		0		0		0
2	100%	2	178	0	0	0	0		0		0		0
Totals			35117		27788		20787		6854		2517		271
OA Temp	% Load	Jul		Aug		Sep		Oct		Nov		Dec	
(3)	(4)	Hours (3)	MBtu (5)	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu	Hours	MBtu
62	6%	8	44	17	83	63	344	123	672	86	470	44	240
57	16%	2	29	3	44	38	554	109	1588	102	1486	82	903
52	27%		0		0	12	284	80	2131	122	2889	77	1823
47	37%		0		0	3	98	55	1803	106	3475	107	3508
42	47%		0		0	1	42	26	1089	86	3603	129	5404
37	57%		0		0		0	8	408	61	3111	121	6171
32	67%		0		0		0	2	120	33	1883	86	5109
27	78%		0		0		0		0	13	900	67	3945
22	88%		0		0		0		0	4	313	24	1880
17	98%		0		0		0		0	1	87	13	1137
12	100%		0		0		0		0		0	3	268
7	100%		0		0		0		0		0	0	0
2	100%		0		0		0		0		0	0	0
Totals			0		0		0		0		0	0	30387

Conduction Loss Calculations												
		Pipe Temperature =	350.1 °F (for 120 psig, see attached steam tables)									
		Insulation Thickness =	2.5 inches									
Nominal Pipe Dia.	Pipe IR $r_a$ (ft)	Steam $h_a$ (1)	Pipe OR $r_b$ (ft)	Still Air $h_b$ (1)	Ins. OR $r_c$ (ft)	Out. Air $h_c$ (1)	k pipe (1) $B \cdot ft / h \cdot sf \cdot ^\circ F$	k ins (1) $B \cdot ft / h \cdot sf \cdot ^\circ F$	Pipe Lnth Ft (2)	Steam (3) Btu/hr $^\circ F$	N. Gas (4) MBtu/hr $^\circ F$	
1"	0.0874	2000	0.0985	1.65	0.307	6.00	27	0.03	5280	744	0.0011	
2"	0.172	2000	0.185	1.65	0.393	6.00	27	0.03	3960	863	0.0012	
3"	0.256	2000	0.274	1.65	0.482	6.00	27	0.03	3960	1161	0.0017	
4"	0.336	2000	0.355	1.65	0.564	6.00	27	0.03	3960	1431	0.0020	
5"	0.421	2000	0.442	1.65	0.650	6.00	27	0.03	3960	1716	0.0025	
6"	0.505	2000	0.529	1.65	0.737	6.00	27	0.03	15840	7995	0.0114	
									Total		0.0199	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OAT (5)	41.4	44.6	53	62.4	70.2	78.2	81.5	80.6	74.2	63.7	51.9	43.7
Hrs/Mo	744	672	744	720	744	720	744	744	720	744	720	744
MB/Mo (6)	4564	4080	4392	4116	4138	3890	3971	3984	3947	4234	4266	4530
(1)	From the Mechanical Engineering Review Manual, Table 3.2 and Table 3.3, see attached pages.											
(2)	Pipe length estimated from General Heating Maps for PBA, pages 73 and 74.											
(3)	From the Mechanical Engineering Review Manual, Equation 3.15, page 3-6, see attached.											
(4)	N. Gas MBtu/hr $^\circ F$ = (Steam Btu/hr $^\circ F$ / boiler eff.) x (1MBtu / 1000000Btu), assumes boiler eff. = 70%.											
(5)	Average outside air temperatures from The Weather Almanac, Fourth Edition, 30 year average monthly temperatures.											
(6)	Conduction Losses MBtu/Mo = N. Gas MBtu/hr $^\circ F$ x (Pipe Temp - OAT) x Hrs/Mo.											



At common temperatures, conductivity in solids varies according to

$$k(T) = k_o(1 + \gamma T) \quad 3.3$$

$\gamma$  is positive for amorphous materials and insulators (e.g., brick, graphite, etc.) and negative for crystalline materials (with the exceptions of aluminum and brass). Tabulated values of  $\gamma$  are not common, having been replaced with tabulations of  $k$  itself versus  $T$  for various common materials. In most calculations, the average thermal conductivity (conductivity at the arithmetic mean temperature) is used, and no other attention is paid to variations in conductivity with temperature.

In liquids, heat is transmitted by longitudinal vibrations, similar to sound waves. According to Bridgeman (1921),

$$k = \frac{3k^*a}{d^2} \quad 3.4$$

Conductivity in water and aqueous solutions increases with increases in temperature up to around 250°F, and then gradually decreases. Conductivity decreases with increased concentrations of aqueous solutions, as it does with most other liquids. Conductivity increases with increases in pressure. Of the non-metallic liquids, water is the best thermal conductor.

The net transport theory can be used to explain heat conduction through gases. Hot molecules move faster than cold molecules, traveling to cold areas with greater frequency than cold molecules travel to hot areas. It can be shown that

$$k = \frac{N\bar{v}fk^*\lambda}{6} \quad 3.5$$

Conductivity in gases increases almost linearly with increases in temperature, but is fairly independent of pressure in common ranges.

The table below gives the thermal conductivities for some of the more common materials. The back of this chapter has a more extensive list. Notice that BTU-ft/hr-ft<sup>2</sup>-°R is the same as BTU/hr-°R-ft. However, these are not the same as BTU-in/hr-°R-ft<sup>2</sup> which is also widely used. Multiply cal-cm/sec-°K-cm<sup>2</sup> by 241.9 to get ft-English units.

Table 3.2

Typical Thermal Conductivities, BTU-ft/hr-ft <sup>2</sup> -°R					
Material	k	Material	k	Material	k
Silver	242	Lead	20.	Hydrogen	.11
Copper	224	Ice	1.3	Fiberglass	.03
Aluminum	117	Concrete	.5	Cork	.025
Brass	56	Glass	.63	Air	.014
Steel 1%C	27	Water	.32	Oxygen	.016

All of the above conductivities were evaluated at 32°F except hydrogen which was evaluated at 100°F.

## 2. Conduction

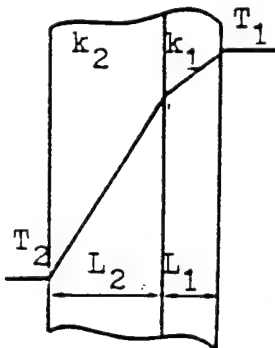
Conduction, the flow of heat through solids, is given by Fourier's law:

$$q = kA\left(\frac{dT}{dL}\right) \quad 3.6$$

If the heat transmission is steady and both  $k$  and  $A$  are constant, heat flow through a single slab of thickness  $L$  is given by equation 3.7:

Figure 3.1

$$q = kA\Delta T/L \quad 3.7$$



The heat flow due to conduction for composite sandwiched materials, as shown in Figure 3.1, is:

$$q = \frac{A\Delta T}{\sum\left(\frac{L_i}{k_i}\right)} \quad 3.8$$

To further complicate the problem, there is usually a film on the exposed surfaces. There may also be a film between layers, although perfect bonding is usually assumed.

To account for films on exposed surfaces without having to measure the film thickness, the film thermal resistance is given by a film coefficient,  $h$ . The heat flow through a film is

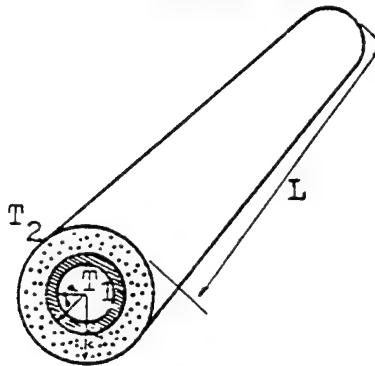
$$q = hA\Delta T \quad 3.9$$

Table 3.3 (5:69)

<u>Film Coefficients in BTU/hr-ft<sup>2</sup>-°F</u>	
No change in state	
air, still	1.65
air, with 15 mph wind	6.00
water	150 to 2000
other gases	3 to 50
gasoline, kerosene, alcohol and other organic solvents	60 to 500
oils	10 to 120
Condensing	
steam	1000 to 3000
organic solvents	150 to 500
light oils	200 to 400
heavy oils	20 to 50
ammonia	500 to 1000
Evaporating	
water	800 to 2000
organic solvents	100 to 300
light oils	150 to 300
heavy oils	10 to 50
ammonia	200 to 400
R-12	100 to 600

The commonly encountered insulated pipe with films can be solved by using equation 3.15, which requires all dimensions to be in feet.

Figure 3.2



$$q = \frac{2\pi L \Delta T}{\frac{1}{r_a h_a} + \frac{\ln(\frac{r_b}{r_a})}{k_{\text{pipe}}} + \frac{1}{r_b h_b} + \frac{\ln(\frac{r_c}{r_b})}{k_{\text{insul}}} + \frac{1}{r_c h_c}} \quad 3.15$$

If the wall and layers are very thin, or if the radii are large so that  $A = A_a = A_c$ , then the effects of curvature can be ignored and equation 3.10 can be used.

### Example 3.2

Liquid oxygen at  $-290^\circ\text{F}$  is stored in a 5' inside diameter, 20' long cylindrical stainless steel tank covered with 1 foot of powdered diatomaceous silica with average thermal conductivity of .022 BTU/ft-hr- $^\circ\text{F}$ . The environment temperature is  $70^\circ\text{F}$  and the wind is 15 mph. The tank walls are  $3/8$ " thick. Compare the heat gain to the liquid oxygen using equations 3.15 and 3.10.

Required data:

material	t	k	h
stainless	.031	28.0	
silica	1.0	.022	
air, outside			6.0
oxygen, inside			$\infty$

Equation 3.15 gives the exact solution as

$$q = \frac{2\pi(20)(70 + 290)}{\frac{\ln(\frac{2.53}{2.50})}{28.0} + \frac{\ln(\frac{3.53}{2.53})}{.022} + \frac{1}{(3.53)(6.0)}} = 2980 \text{ BTU/hr}$$

If the effects of curvature are ignored, equation 3.10 predicts the heat loss based on the outside area to be:

$$q = \frac{2\pi(3.53)(20)(70+290)}{\frac{.031}{28.0} + \frac{1.0}{.022} + \frac{1}{6}} = 3500 \text{ BTU/hr}$$

Since the addition of a covering (insulation) to a bare pipe also increases the surface area, adding insulation up to the critical thickness will actually increase the heat loss above bare-pipe levels. This critical radius is usually very small, and is most relevant in the cases of thin wires or capillaries. The critical radius is given by:

$$r_{\text{critical}} = \frac{k_{\text{insulation}}}{h} \quad 3.16$$

# CONSTRUCTION COST ESTIMATE

Project: Repair Existing Steam Pipe & Fittings  
 Location: Pine Bluff Arsenal, AR  
 Basis: Schematic Design  
 ECO Number: H1-A

RS&H No.: 694-1331-004  
 Date: 6/27/96  
 Estimator: GWF  
 Filename: EST-H1A.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR (1)		TOTAL COST	SOURCE	
	No.	Unit	\$/Unit	Total	\$/Unit	Total		Material	Labor
90° Elbows 1"	3	Ea	2.29	7	37	111	118	MMp145	MMp145
2"	1	Ea	6.95	7	44	44	51	MMp145	MMp145
6"	2	Ea	43	86	86	172	258	MMp158	MMp158
Gaskets 2"	2	Ea	4.87	10	37	74	84	MMp 157	MMp 157
Gage pig tail 1"	2	Ea	5	10	10	20	30	Estimate	Estimate
Piping 1"	8	LF	2.5	20	8.9	71	91	MMp 139	MMp 139
2"	2	LF	4.49	9	13.5	27	36	MMp 139	MMp 139
Tees 1"	2	Ea	2.9	6	60	120	126	MMp 145	MMp 145
Steam Traps 1"	18	Ea	234	4,212	54	972	5,184	MMp 263	MMp 263
2"	2	Ea	590	1,180	81	162	1,342	MMp 264	MMp 264
Unions 1"	1	Ea	28	28	30	30	58	MMp 157	MMp 157
Valves 1"	45	Ea	26	1,170	25.3	1,139	2,309	MMp 188	MMp 188
2"	13	Ea	59.5	774	44	572	1,346	MMp 188	MMp 188
3"	9	Ea	195	1,755	67	603	2,358	MMp 188	MMp 188
4"	4	Ea	940	3,760	288	1,152	4,912	MMp 196	MMp 196
6"	13	Ea	1475	19,175	448	5,824	24,999	MMp 196	MMp 196
Wyes 1"	1	Ea	13.25	13	30.3	30	43	MMp 271	MMp 271
Asbestos Abatement	128	Ea	11.5	1,472	46	5,888	7,360	MMp 24	MMp 24
Asbestos Disposal	6	CY	160	960	0	0	960	MMp 24	MMp 24
Insulation (2)	271	L.F.	4.06	1,100	3.16	856	1,956	MMp 239	MMp 239
Personnel hoist rental	2	Mo.	1450	2,900		0	2,900	MMp 15	MMp 15
Subtotal Bare Costs				38,654		17,867	56,521		
Retrofit Cost Factors			5%	1,933	9%	1,608	3,541	MMp6	MMp6
Subtotal				40,587		19,475	60,062		
City Cost Index			0.952	(1,948)	0.632	(7,167)	(9,115)	MMp533	MMp533
Subtotal				38,639		12,308	50,947		
OH & Profit Markups			10%	3,864	53%	6,523	10,387	MMp7	MMp475
Subtotal				42,503		18,831	61,334		
State Sales Taxes			4.5%	1,913		N.A.	1,913	MMp476	
Subtotal				44,416		18,831	63,247		
Contingency			10%	4,442	10%	1,883	6,325	MEp6	MEp6
Total Construction Cost				48,858		20,714	\$69,572		
Design Fee				N.A.	6.0%	4,174	4,174		
SIOH				N.A.	6.0%	4,174	4,174		
Total Project Cost				48,858		29,062	\$77,920		

## LEGEND:

- MEp### 1996 Means Electrical Cost Data, page ###.  
 MMp### 1996 Means Mechanical Cost Data, page ###.  
 Note (1) Except for asbestos and insulation items, labor rates are doubled to cover cost for removal of existing material.  
 Note (2) From Means, assumes 3 L.F. per fitting; uses cost for 4" diameter as an average.

A.5.H1-23

PBA  
Leak Survey

ECO H1-A

area	building	fitting	characterization	size	action
31	220/150	Trap	1	1	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace
31	520	Valve	5	2	Replace
31	520	Trap	4	1	Replace
31	520	Gasket	4	2	Replace
31	529	Valve	2	1	Replace
31	530	Gasket	7	2	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Trap	1	2	Replace
31	620	Valve	3	1	Replace
31	630	Valve	3	4	Replace
31	630	Valve	1	2	Replace

AG - WP Above ground tanks  
IG - WP In-ground tanks  
HL - High line

A.5.H1-24

**PBA**  
Leak Survey

ECO HI-A

area	building	fitting	characterization	size	action
32	trailers	Trap	3	1	Replace
32	060	Valve	3	1	Replace
32	060	Valve	2	6	Replace
32	060	Valve	1	6	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	516	Valve	2	2	Replace
32	520	Valve	2	3	Replace
32	520	Valve	1	1	Replace
32	529	Trap	5	2	Replace
32	530	Valve	1	6	Replace
32	530	Valve	2	1	Replace
32	530	Valve	3	2	Replace
32	540	Valve	6	1	Replace
32	610	Trap	3	1	Replace
32	619	Valve	4	3	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	639	Valve	5	1	Replace
32	640	Valve	1	2	Replace
32	640	Trap	2	1	Replace
32	720	elbow	7	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace

AG - WP Above ground tanks  
IG - WP In-ground tanks  
HL - High line

A.5.HI-25

**PBA**  
Leak Survey

ECO HI-A

area	building	fitting	characterization	size	action
33	060	Valve	2	6	Replace
33	060	Valve	2	6	Replace
33	060	Valve	3	1	Replace
33	060	elbow	8	6	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
33	550	Valve	2	2	Replace
33	579	y	3	1	Replace
33	620	Valve	3	2	Replace
33	630	Valve	3	3	Replace
33	630	Valve	2	2	Replace
33	640	Valve	1	3	Replace
33	640	Valve	1	1	Replace
33	729	Valve	1	2	Replace

AG - WP Above ground tanks  
IG - WP In-ground tanks  
HL - High line

A.5.HI-26

# PBA Leak Survey

ECO #1-A

area	building	fitting	characterization	size	action
34	110	Valve	3	1	Replace
34	110	Valve	1	4	Replace
34	118	Valve	10	1	Replace
34	170	Valve	2	2	Replace
34	170	Valve	1	6	Replace
34	170	Valve	1	6	Replace
34	182	Valve	3	4	Replace
34	184	elbow	1	6	Replace
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	184	Valve	4	6	Replace
34	185	Valve	6	3	Replace
34	197	Valve	10	1	Replace
34	350	Valve	7	2	Replace
34	630	Valve	2	4	Replace
34	640	elbow	3	2	Replace
34	640	trap	1	1	Replace
34	640	union	4	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	AG	elbow		1	Replace
34	AG	pig tail		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	T		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
34	HL	Valve	1	1	Replace
34	HL	Valve	1	6	Replace
34	HL	Valve	1	6	Replace
34	IG	elbow	8	1	Replace

AG - WP Above ground tanks (not operating during survey, assume same as IG)  
 IG - WP In-ground tanks  
 HL - High line

A.5.HI-27



sort fitt'g

ECO H1-A

area	building	fitting	characterization	size	action
32	720	elbow	7	1	Replace
34	IG	elbow	8	1	Replace
34	AG	elbow		1	Replace
34	640	elbow	3	2	Replace
33	060	elbow	8	6	Replace
34	184	elbow	1	6	Replace
31	520	Gasket	4	2	Replace
31	530	Gasket	7	2	Replace
34	IG	pig tail	6	1	Replace
34	AG	pig tail		1	Replace
34	IG	pipe	1	1	Replace
34	IG	pipe	7	1	Replace
34	IG	pipe	8	1	Replace
34	IG	pipe	8	1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
34	IG	T	3	1	Replace
34	AG	T		1	Replace
31	520	Trap	4	1	Replace
31	220/150	Trap	1	1	Replace
32	610	Trap	3	1	Replace
32	640	Trap	2	1	Replace
32	trailers	Trap	3	1	Replace
34	640	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	8	1	Replace
34	IG	trap	3	1	Replace
34	IG	trap	3	1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
31	620	Trap	1	2	Replace
32	529	Trap	5	2	Replace
34	640	union	4	1	Replace
31	529	Valve	2	1	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Valve	3	1	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	520	Valve	1	1	Replace
32	530	Valve	2	1	Replace
32	540	Valve	6	1	Replace
32	639	Valve	5	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace
32	060	Valve	3	1	Replace
33	640	Valve	1	1	Replace
33	060	Valve	3	1	Replace
34	110	Valve	3	1	Replace
34	118	Valve	10	1	Replace

AG-WP Above ground tanks  
 IG - WP In-ground str'g tanks  
 HL - High line

A.5.H1-28

sort fitt'g

ECO HI-A

area	building	fitting	characterization	size	action
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	197	Valve	10	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	HL	Valve	1	1	Replace
34	IG	Valve	5	1	Replace
34	IG	Valve	1	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	6	1	Replace
34	IG	Valve	4	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	9	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	2	1	Replace
34	slag pit	Valve	8	1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
31	520	Valve	5	2	Replace
31	630	Valve	1	2	Replace
32	516	Valve	2	2	Replace
32	530	Valve	3	2	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	640	Valve	1	2	Replace
33	550	Valve	2	2	Replace
33	620	Valve	3	2	Replace
33	630	Valve	2	2	Replace
33	729	Valve	1	2	Replace
34	170	Valve	2	2	Replace
34	350	Valve	7	2	Replace
32	520	Valve	2	3	Replace
32	619	Valve	4	3	Replace
33	630	Valve	3	3	Replace
33	640	Valve	1	3	Replace
34	185	Valve	6	3	Replace
34	IG	Valve	6	3	Replace
34	IG	Valve	1	3	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
31	630	Valve	3	4	Replace
34	110	Valve	1	4	Replace
34	182	Valve	3	4	Replace
34	630	Valve	2	4	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace

AG-WP Above ground tanks  
 IG - WP In-ground str'g tanks  
 HL - High line

A.5.HI-29

area	building	fitting	characterization	size	action
32	720	elbow	7	1	Replace
34	IG	elbow	8	1	Replace
34	AG	elbow		1	Replace
34	IG	pig tail	6	1	Replace
34	AG	pig tail		1	Replace
34	IG	pipe	1	1	Replace
34	IG	pipe	7	1	Replace
34	IG	pipe	8	1	Replace
34	IG	pipe	8	1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	AG	pipe		1	Replace
34	IG	T	3	1	Replace
34	AG	T		1	Replace
31	520	Trap	4	1	Replace
31	220/150	Trap	1	1	Replace
32	610	Trap	3	1	Replace
32	640	Trap	2	1	Replace
32	trailers	Trap	3	1	Replace
34	640	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	1	1	Replace
34	IG	trap	8	1	Replace
34	IG	trap	3	1	Replace
34	IG	trap	3	1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	AG	trap		1	Replace
34	640	union	4	1	Replace
31	529	Valve	2	1	Replace
31	540	Valve	1	1	Replace
31	620	Valve	2	1	Replace
31	620	Valve	3	1	Replace
32	169	Valve	1	1	Replace
32	440	Valve	1	1	Replace
32	520	Valve	1	1	Replace
32	530	Valve	2	1	Replace
32	540	Valve	6	1	Replace
32	639	Valve	5	1	Replace
32	720	Valve	3	1	Replace
32	720	Valve	5	1	Replace
32	060	Valve	3	1	Replace
33	640	Valve	1	1	Replace
33	060	Valve	3	1	Replace
34	110	Valve	3	1	Replace

AG - WP above ground tanks

IG - WP in-ground tanks

HL - High line

Sort size

ECO HI-A

area	building	fitting	characterization	size	action
34	118	Valve	10	1	Replace
34	184	Valve	5	1	Replace
34	184	Valve	4	1	Replace
34	197	Valve	10	1	Replace
34	640	Valve	1	1	Replace
34	650	Valve	2	1	Replace
34	660	Valve	1	1	Replace
34	660	Valve	2	1	Replace
34	660	Valve	3	1	Replace
34	HL	Valve	1	1	Replace
34	IG	Valve	5	1	Replace
34	IG	Valve	1	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	6	1	Replace
34	IG	Valve	4	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	9	1	Replace
34	IG	Valve	3	1	Replace
34	IG	Valve	2	1	Replace
34	slag pit	Valve	8	1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
34	AG	Valve		1	Replace
33	579	y	3	1	Replace
34	640	elbow	3	2	Replace
31	520	Gasket	4	2	Replace
31	530	Gasket	7	2	Replace
33	540	pipe	5	2	Replace
33	550	pipe	2	2	Replace
31	620	Trap	1	2	Replace
32	529	Trap	5	2	Replace
31	520	Valve	5	2	Replace
31	630	Valve	1	2	Replace
32	516	Valve	2	2	Replace
32	530	Valve	3	2	Replace
32	620	Valve	4	2	Replace
32	631	Valve	3	2	Replace
32	640	Valve	1	2	Replace
33	550	Valve	2	2	Replace
33	620	Valve	3	2	Replace
33	630	Valve	2	2	Replace
33	729	Valve	1	2	Replace
34	170	Valve	2	2	Replace
34	350	Valve	7	2	Replace

AG - WP above ground tanks

IG - WP in-ground tanks

HL - High line

A.5.HI-31

Sort size

ECO H1-A

area	building	fitting	characterization	size	action
32	520	Valve	2	3	Replace
32	619	Valve	4	3	Replace
33	630	Valve	3	3	Replace
33	640	Valve	1	3	Replace
34	185	Valve	6	3	Replace
34	IG	Valve	6	3	Replace
34	IG	Valve	1	3	Replace
34	AG	Valve		3	Replace
34	AG	Valve		3	Replace
31	630	Valve	3	4	Replace
34	110	Valve	1	4	Replace
34	182	Valve	3	4	Replace
34	630	Valve	2	4	Replace
33	060	elbow	8	6	Replace
34	184	elbow	1	6	Replace
31	080	Valve	7	6	Replace
31	080	Valve	1	6	Replace
31	080	Valve	1	6	Replace
32	530	Valve	1	6	Replace
32	060	Valve	2	6	Replace
32	060	Valve	1	6	Replace
33	060	Valve	2	6	Replace
33	060	Valve	2	6	Replace
34	170	Valve	1	6	Replace
34	170	Valve	1	6	Replace
34	184	Valve	4	6	Replace
34	HL	Valve	1	6	Replace
34	HL	Valve	1	6	Replace
size	thkness	area	No	CY	
1	2	0.5	80	1	
2	2	1	40	1	
3	2	1.5	27	1	
4	2	2	16	1	
6	2	2.5	90	2	
				6	

AG - WP above ground tanks  
 IG - WP in-ground tanks  
 HL - High line

A.5.H1-32

## ENERGY PROJECT SUMMARY SHEET

<b>Installation and Location</b>	Pine Bluff Arsenal, Pine Bluff, Arkansas
<b>Project Title</b>	Boiler Efficiency Improvements
<b>Project Funding Category</b>	Federal Energy Management Program (FEMP)
<b>Total Investment</b>	\$93,000
<b>Annual Cost Savings</b>	\$26,700
<b>Savings-to-Invest. Ratio (SIR)</b>	5.34
<b>Simple Payback Period</b>	3.5 Years

### Contents

DD Form 1391, Front Sheet

Attachment 1 - Life Cycle Cost Analysis Summary

Attachment 2 - Description of Work to be Accomplished

Attachment 3 - Savings Calculations, Cost Estimate and Back-up Data

1. COMPONENT <b>ARMY</b>		FY 19__ <b>MILITARY CONSTRUCTION PROJECT DATA</b>		2. DATE September 6, 1996	
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas			4. PROJECT TITLE Boiler Efficiency Improvements - FEMP		
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER		8. PROJECT COST (\$000) \$93	
9. COST ESTIMATES					
ITEM	U/M	QUANTITY	UNIT COST	COST (\$000)	
Remove stacks, install economizers, piping, valves and controls on two York-Shipley boilers. Reinstall stacks and repair roof. See attached detailed estimate.				\$69.6	
Install and adjust jackshaft cam kits on the two boilers in Building 33-060. See attached detailed estimate.				\$5.8	
Subtotal Construction Cost				\$75.4	
Contingency (10%)				\$7.5	
Total Construction Cost				\$82.9	
Design Fee (6%)				\$5.0	
SIOH (6%)				\$5.0	
Total Cost				\$92.9	
Total Requested (rounded)				\$93	
10. DESCRIPTION OF PROPOSED CONSTRUCTION					
<p>The scope of work for this project includes the following two items:</p> <p>1. Purchase and install stack gas economizers on the two York-Shipley boilers located in Building 32-060. The top portion of the stacks will be removed, the economizers and all necessary boiler feedwater piping, valves and controls will be installed to allow the boiler feedwater to be heated by the hot combustion gases. The stacks will be reinstalled and the roof around the stacks will be repaired where required.</p> <p>2. An adjustable cam kit will be purchased and installed on each boiler located in Building 33-060. The cams will be positioned in the connecting link between the burner jack shaft and the forced draft inlet vane. After they are installed, the cams will be set up to provide proper proportioning of the air and fuel over the entire operating load range of the boilers.</p>					

## ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data



**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 1**

**LIFE CYCLE COST ANALYSIS SUMMARY**

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: H2D-H3B

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)      LCCID    FY95 (92)

INSTALLATION & LOCATION: P B ARSENAL    REGION NOS.    6    CENSUS: 3

PROJECT NO. & TITLE: H2D&H3B    BOILER EFFICIENCY IMPROVEMENTS

FISCAL YEAR 1997    DISCRETE PORTION NAME: ECO-H2D AND ECO-H3B COMBINED

ANALYSIS DATE: 08-22-96    ECONOMIC LIFE 20 YEARS    PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	\$	82990.	
B. SIOH	\$	4980.	
C. DESIGN COST	\$	4980.	
D. TOTAL COST (1A+1B+1C)	\$	92950.	
E. SALVAGE VALUE OF EXISTING EQUIPMENT	\$	0.	
F. PUBLIC UTILITY COMPANY REBATE	\$	0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)	\$		92950.

2. ENERGY SAVINGS (+) / COST (-)

DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 16.79	0.	\$ 0.	15.08	\$ 0.
B. DIST	\$ .00	0.	\$ 0.	18.57	\$ 0.
C. RESID	\$ .00	0.	\$ 0.	21.02	\$ 0.
D. NAT G	\$ 2.81	9506.	\$ 26712.	18.58	\$ 496306.
E. COAL	\$ .00	0.	\$ 0.	16.83	\$ 0.
F. PPG	\$ .00	0.	\$ 0.	17.38	\$ 0.
M. DEMAND SAVINGS			\$ 0.	14.88	\$ 0.
N. TOTAL		9506.	\$ 26712.		\$ 496306.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	0.
(1) DISCOUNT FACTOR (TABLE A)		14.88	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTOR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	\$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)\$ 0.

4. FIRST YEAR DOLLAR SAVINGS  $2N3+3A+(3Bd1/(YRS \text{ ECONOMIC LIFE}))$ \$ 26712.

5. SIMPLE PAYBACK PERIOD (1G/4) 3.48 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) \$ 496306.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 5.34  
(IF < 1 PROJECT DOES NOT QUALIFY)

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 2**

**DESCRIPTION OF WORK TO BE ACCOMPLISHED**

## ECO-H2

### Modifications and improvements to boilers in Building 32-060.

#### Description

This project consist of installing stack gas economizers on the two York-Shipley boilers. The top portion of the stacks will be removed, the economizers and all necessary boiler feedwater piping, valves and controls will be installed to allow the boiler feedwater to be heated by the hot combustion gases. The stacks will be reinstalled and the roof around the stacks will be repaired where required.

During the course of preparing this report, demolition of the existing boilers and preparation for installing the surplus boilers was started. This ECO was added and analyzed because the current construction contract for the boiler replacement project does not include the purchase and installation of economizers.

The existing boilers are being removed and replaced with two new York Shipley, 600 hp, fire tube boilers. The new boilers are equipped with O<sub>2</sub> trim to optimize the fuel-to-air ratio. These controls will allow the new boilers to operate at an efficiency of about 80 percent when operating between ten percent load and full load.

The economizers will allow the new boilers to maintain the exhaust gas temperature at about 250 degrees F over the boiler's entire operating load range. Fire tube boilers typically have exhaust gas temperatures that range between 50 degrees F to 150 degrees F above the saturation temperature corresponding to their operating pressure. PBA operates the boilers at a pressure of about 130 psig. The corresponding saturation temperature would be 355 degrees F, and the exit gas temperature should be between 405 degrees F and 505 degrees F. The economizer can reduce the exhaust gas temperature to 250 degrees F. Boiler efficiency increases about one percent for every 40 degrees F reduction in exhaust gas temperature. Therefore, the boilers will pick up four to six efficiency points by adding an economizer.

The energy savings calculations assume adding an economizer and a stack gas temperature control loop to maintain the stack temperature at 250 degrees F will raise the operating efficiency of the York-Shipley boilers from about 80 percent to approximately 85 percent.

## **ECO-H3**

### **Modifications and improvements to boilers in Building 33-060.**

#### **Description**

An adjustable cam kit will be purchased and installed on each boiler. The cams are positioned in the connecting link between the burner jack shaft and the forced draft inlet vane. After they are installed, the cams will be set up to provide proper proportioning of the air and fuel over the entire operating load range of the boilers.

The existing boilers were originally installed in 1942 during the beginning of World War II. The burners were replaced about 20 years ago but were never properly adjusted. The existing connecting links between the burner jack shaft and the forced draft fan do not permit proper adjustment of the air-to-fuel ratio over the operating load range of the boiler. As a result the boilers are currently operating with far too much excess air. Field tests at various operating loads indicate the excess air for these boilers ranges from 72 percent to 191 percent. The normal, and most efficient, operating range is 10 percent to 15 percent excess air.

The high excess air amounts are reducing the operating efficiency of these boilers by three to eight percent. The calculated annual average efficiency based on the average annual load factor for these boilers is about 75 percent. Installation of the adjustable cam will maintain the residual stack gas O<sub>2</sub> concentration at about 1.7 percent and the excess air at approximately 10 percent when firing natural gas. This retrofit will allow the boilers to operate at an efficiency of about 80 percent over their entire operating load range.

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 3**

**SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA**

# Pine Bluff Arsenal

## Energy Savings Calculations

ECO Number:	H2D	Notes
Building Number:	32-060	
Natural Gas consumption (MBtu/Yr):	107,613	(1)
Current Boiler Efficiency:	0.80	(2)
Boiler Efficiency w/ Economizer:	0.85	(3)

**Notes:**

- (1) Assumes steam leaks are repaired, see attached calculation sheet.
- (2) Efficiency of a new boiler with properly operating air-fuel controls.
- (3) Efficiency with an economizer,  $(450^{\circ}-250^{\circ})/40 = 5\%$  improvement.

Energy Savings = (Improved efficiency - Current efficiency) x Natural gas consumption

$$= (0.85 - 0.80) \times 107,613 \text{ MBtu/Yr}$$

$$\text{Energy Savings} = 5,381 \text{ MBtu/Yr}$$

## CONSTRUCTION COST ESTIMATE

Project: Modifications & Improvements to boilers in Bldg.32-060  
Location: Pine Bluff Arsenal, AR  
Basis: Schematic Design  
ECO Number: H2-D: Retrofit economizers on surplus boilers.

RS&H No.: 694-1331-004  
Date: 8/15/96  
Estimator: WTT  
Filename: EST-H2D.XLS

[illegible]

**LEGEND:**

MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
MRp###	1991 Means Repair and Remodling Cost Data, page ###, exclated at 3%/yr.
Vendor	Vendor estimate, see attached telephone call confirmation.





# Telephone Call Confirmation

Project Number 694-1331-004

Local \_\_\_\_\_ L.D. X Placed X Rec'd \_\_\_\_\_ Date 6-4-96

Conversed with MARK CUTTER of McCain Engineering  
PELHAM ALABAMA.

Regarding ECONOMIZER FOR YORK SHIPLEY BOILER

MAT'L COST  $\approx$  \$18,000 CIRCULAR ECONOMIZER

INSTALLATION  $\approx$  \$5000 BECAUSE NOT RETROFIT IF  
INSTALLED DURING CONSTRUCTION

George Fallon JR

Distribution:

A.5.H2-16

**Pine Bluff Arsenal**  
Energy Savings Calculations

ECO Number:	H3B	Notes
Building Number:	33-060	
Natural Gas consumption (MBtu/Yr):	82,495	(1)
Current Boiler Efficiency:	0.75	(2)
New/Improved Boiler Efficiency:	0.80	(3)

Notes:

- (1) Assumes steam leaks are repaired, see attached calculation sheet.
- (2) Actual efficiency calculated from field measurements.
- (3) Efficiency of a new or properly operating boiler.

Energy Savings = (Improved efficiency - Current efficiency) x Natural gas consumption

$$= (0.80 - 0.75) \times 82,495 \text{ MBtu/yr}$$

Energy Savings = 4,125 MBtu/yr

## CONSTRUCTION COST ESTIMATE

Project: Modifications & Improvements to boilers in Bldg.33-060  
Location: Pine Bluff Arsenal, AR  
Basis: Schematic Design  
ECO Number: H3-B: Improve efficiency of existing boilers

RS&H No.: 694-1331-004  
Date: 6/26/96  
Estimator: GWF  
Filename: EST-H3B.XLS

[illegible]

**LEGEND:**

Note (1)	Assumes 3 days to install, \$800 per day for labor and expenses.
MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
Vendor	Vendor quote, see attached fax.

A.5.H3-7

## PINE BLUFF ARSENAL

### Annual Energy Consumption in Production Area Boiler Buildings

#### 1995 Energy Use Data (from boiler operating logs)

Area 32 Nat Gas Consumption (MBtu/yr) = 163,392

Area 33 Nat Gas Consumption (MBtu/yr) = 125,255

Area 34 Nat Gas Consumption (MBtu/yr) = 203,467

#### 1995 Natural Gas Consumption in 32, 33 & 34 Boilers

Total Consumption (MBtu/yr) = Sum of Areas 32, 33 and 34

Total Consumption = 163,392 + 125,255 + 203,467

Total Consumption = 492,114 MBtu/yr

#### Percent Share of Total for Each Area

Area 32 = 163,392 / 492,114 = 33%

Area 33 = 125,255 / 492,114 = 25%

Area 34 = 203,467 / 492,114 = 41%

#### Energy Loss From Steam Leaks

Estimated energy loss due to steam leaks (1995) = 168,000 MBtu/yr

#### Estimated Energy Consumption w/o Steam Leaks

Forecast Consumption = Total Consumption for 1995 - Steam Leaks for 1995

= 492,114 - 168,000

= 324,114 MBtu/yr

#### Forecast Area Energy Consumption

Forecast area 32 = 324,114 × 33% = 107,613 MBtu/yr

Forecast area 33 = 324,114 × 25% = 82,495 MBtu/yr

Forecast area 34 = 324,114 × 41% = 134,007 MBtu/yr

A.5, H3-B

B#-CALC.XLS tab all

### Determination of Average Annual boiler efficiency

To determine the average annual boiler efficiency, stack gas analysis data was taken at five different boiler loads. The five load points ranged between the boiler's published 100% and 200% capacity because that is the range where the boiler typically operates. A curve was then drawn through the data points.

A monthly load factor was calculated from boiler operating logs. An annual average load factor was calculated from the monthly data and used to select an annual average boiler efficiency. The table below summarizes the results:

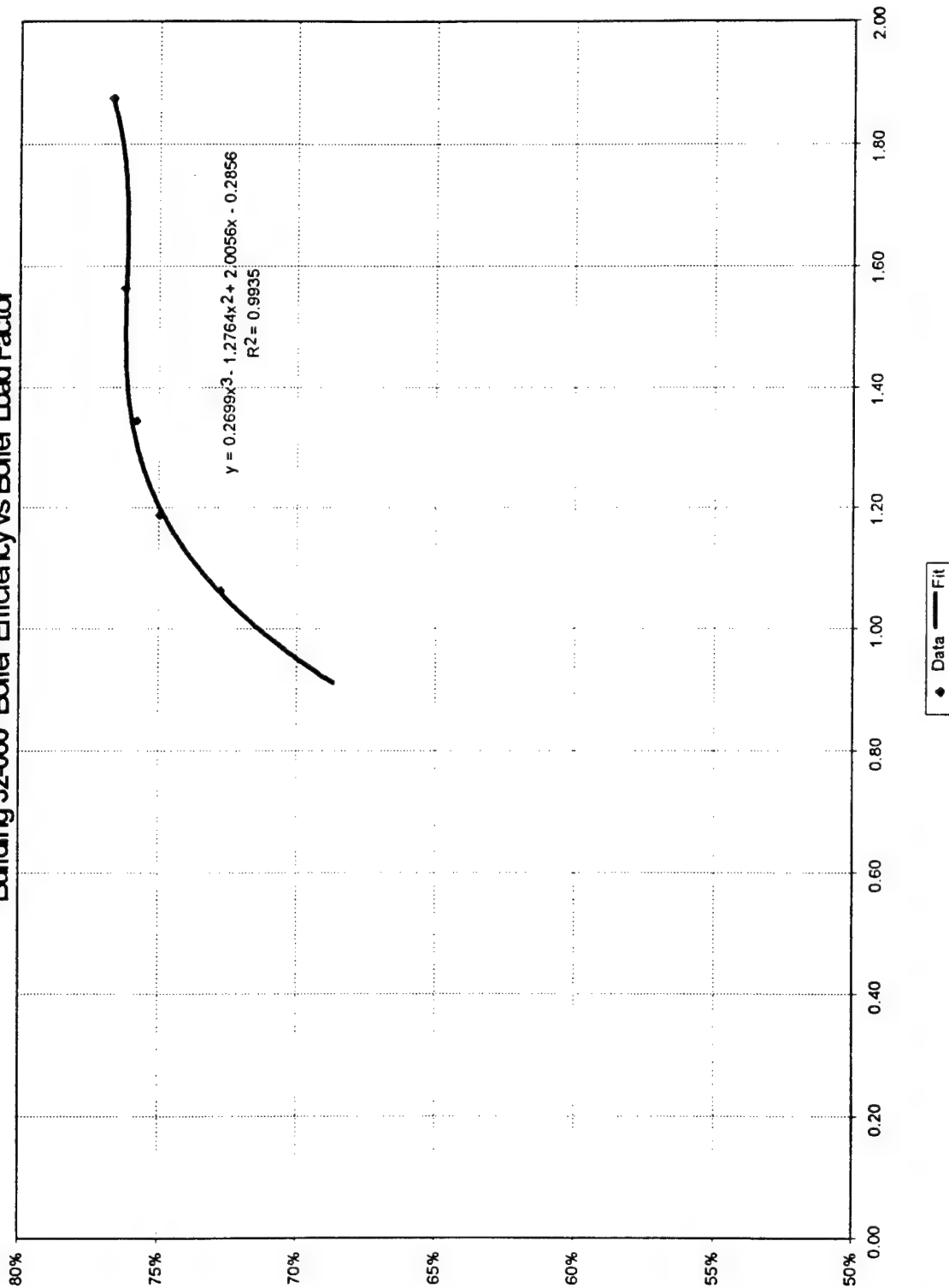
<u>Building</u>	<u>Average Annual Load factor (1)</u>	<u>Average Annual Efficiency (2)</u>
32-060	110%	74%
33-060	125%	75%
34-140	160%	72%

(1) Calculated from boiler operating logs. Boilers usually operate between 100% and 200% of published boiler capacity.

(2) Average annual efficiency of the boilers determined from attached graph at the average annual load factor.

# PINE BLUFF ARSENAL

Building 32-060 Boiler Efficiency vs Boiler Load Factor



A.5.H3-10



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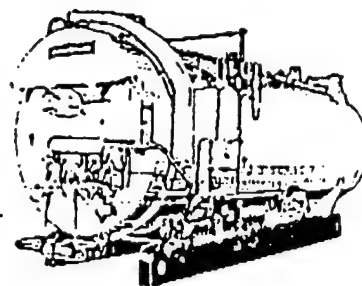
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AS POSSIBLE.

A.5.H3-13

## ENERGY PROJECT SUMMARY SHEET

<b>Installation and Location</b>	Pine Bluff Arsenal, Pine Bluff, Arkansas
<b>Project Title</b>	Repair Compressed Air Pipe and Fittings
<b>Project Funding Category</b>	Federal Energy Management Program (FEMP)
<b>Total Investment</b>	\$84,000
<b>Annual Cost Savings</b>	\$98,200
<b>Savings-to-Invest. Ratio (SIR)</b>	17.7
<b>Simple Payback Period</b>	0.9 Years

### Contents

DD Form 1391, Front Sheet

Attachment 1 - Life Cycle Cost Analysis Summary

Attachment 2 - Description of Work to be Accomplished

Attachment 3 - Savings Calculations, Cost Estimate and Back-up Data



1. COMPONENT <b>ARMY</b>		FY 19__ <b>MILITARY CONSTRUCTION PROJECT DATA</b>		2. DATE September 6, 1996	
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas			4. PROJECT TITLE Repair Compressed Air Pipe and Fittings - FEMP		
5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER		8. PROJECT COST (\$000) \$84	
9. COST ESTIMATES					
ITEM		U/M	QUANTITY	UNIT COST	COST (\$000)
Locate compressed air leaks. Repair/replace leaking piping, valves and fittings. See attached detailed estimate.					
Subtotal Construction Cost					\$67.9
Contingency (10%)					\$6.8
Total Construction Cost					\$74.7
Design Fee (6%)					\$4.5
SIOH (6%)					\$4.5
Total Cost					\$83.7
Total Requested (rounded)					\$84
10. DESCRIPTION OF PROPOSED CONSTRUCTION					
<p>The scope of work for this project consists of repairing and/or replacing all of the failed valves, fittings and pipe sections on the existing air distribution piping system served by the compressors in Buildings 32-060, 33-060 and 34-140. An ultrasonic leak detector will be utilized to locate the compressed air leaks.</p>					

## ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 1**

**LIFE CYCLE COST ANALYSIS SUMMARY**

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: ECO-C3

LCCID FY95 (92)

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: ECO-C3 COMPRESSED AIR SYSTEM MODIFICATIONS

FISCAL YEAR 1997 DISCRETE PORTION NAME: OPTION C - REPAIR CA PIPING

ANALYSIS DATE: 07-02-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	\$	74718.		
B. SIOH	\$	4483.		
C. DESIGN COST	\$	4483.		
D. TOTAL COST (1A+1B+1C)	\$	83684.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT	\$		0.	
F. PUBLIC UTILITY COMPANY REBATE	\$		0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)	\$			83684.

2. ENERGY SAVINGS (+) / COST (-)

DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 16.79	5847.	\$ 98176.	15.08	\$ 1480497.
B. DIST	\$ .00	0.	\$ 0.	18.57	\$ 0.
C. RESID	\$ .00	0.	\$ 0.	21.02	\$ 0.
D. NAT G	\$ 2.81	0.	\$ 0.	18.58	\$ 0.
E. COAL	\$ .00	0.	\$ 0.	16.83	\$ 0.
F. PPG	\$ .00	0.	\$ 0.	17.38	\$ 0.
M. DEMAND SAVINGS			\$ 0.	14.88	\$ 0.
N. TOTAL		5847.	\$ 98176.		\$ 1480497.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	0.
(1) DISCOUNT FACTOR (TABLE A)		14.88	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTOR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
------	------------------------------	-----------------	-------------------------	---

d. TOTAL	\$	0.		0.
----------	----	----	--	----

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)	\$	0.
---	----	----

4. FIRST YEAR DOLLAR SAVINGS $2N3+3A+(3Bd1/(YRS \text{ ECONOMIC LIFE}))$	\$	98176.
--	----	--------

5. SIMPLE PAYBACK PERIOD (1G/4)	.85 YEARS
---------------------------------	-----------

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C)	\$	1480497.
--	----	----------

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)=	17.69
(IF < 1 PROJECT DOES NOT QUALIFY)	

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 2**

**DESCRIPTION OF WORK TO BE ACCOMPLISHED**

## **ECO-C3**

### **Modifications and improvements to the compressed air system.**

#### **Description**

This project consist of locating compressed air leaks with a ultrasonic leak detector and then repairing and/or replacing all of the failed valves, fittings and pipe sections on the existing air distribution piping system served by the compressors in Buildings 32-060, 33-060 and 34-140.

Discussions with the air compressor operating staff indicated between two and three compressors operate during non-production times and between four and six of the compressors will operate during production times. Since very little process air is required during non-production hours, the analysis assumes one compressor operates at full load and one compressor operates at half load during this time to supply leaks in the distribution system. Energy and cost savings are based on reduced compressor air supply requirements due to elimination of the leaks in the distribution system.

A comprehensive survey of the compressed air lines was not included in the Scope of Work for this study, however, many compressed air leaks were observed during the survey of the steam distribution system. The analysis uses the air flow from a 1/16 inch diameter leak to calculate the number of leaks in the system. The project construction cost was then calculated based on the calculated number of leaks.

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 3**

**SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA**



SUBJECT PBA ELEC & HTG STUDY  
DEDICATED COMPRESSORS  
DESIGNER W. TODD  
CHECKER \_\_\_\_\_

AEP NO 694-1331-004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 6-25-96  
DATE \_\_\_\_\_

## ECO-C3-A, INSTALL DEDICATED COMPRESSORS

Compressed Air Demand:

Bldg. No.	CFM Req'd (1)	No. Compressors Req'd.			
		10 CFM	100 CFM	200 CFM	600 CFM
31530	200 CFM			1	
31620	200			1	
31630	1800				3
31640	10	1			
31720	10	1			
Subtotals	2220	2	0	2	3
32070	10	1			
32230	400			2	
32270	1800				3
32610	100		1		
32620	178			1	
32640	1200				2
Subtotals	3688	1	1	3	5
33530	2100		1	1	3
33620	10	1			
33670	600				1
Subtotals	2710	1	1	1	4
34110	600				1
34630	120			1	
34640	100		1		
Subtotals	820	0	1	1	1
Totals	9438 CFM	4	3	7	13

(1) From CDG Utility Study, Exhibit G, see attached pages.





SUBJECT PBA ELEC. HTG STUDY  
DEDICATED COMPRESSORS  
DESIGNER W. Todd  
CHECKER \_\_\_\_\_

AEP NO 694 1331 004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 6-25-96  
DATE \_\_\_\_\_

### ECD - C3 (continued)

According to the PBA production staff, Buildings 31620, 31630 and 31720 are in layaway. There are also 2-600 cfm compressor packages available (already purchased by DPW) to install. The 10 cfm compressors are very small and will not be considered in the cost estimate for this analysis. The number of compressors required now becomes:

100 cfm : 3 each

200 cfm : 7 - 1 (Bldg. 31620) = 6 each

600 cfm : 13 - 3 (Bldg. 31630) - 2 (surplus) = 8 each

According to the DPW operating staff: 2 to 3 of the existing 6 compressors operate during non-production times and 4 to 6 of them operate during production. The existing compressors have a rated output of 825 cfm each.

A detailed survey of the C.A. system was not included in the scope of this study, however, during the steam line survey many compressed air leaks were observed. The following assumptions / estimates will be used for the analysis of this ECD:

- The process load during non-production is  $\sim 412$  cfm ( $\frac{1}{2}$  compressor)
- Leaks at or inside process buildings is  $\sim 412$  cfm ( $\frac{1}{2}$  compressor)
- Leaks in the main distribution piping is  $\sim 1237$  cfm ( $1\frac{1}{2}$  compressors)
- Process air load = 5 compressors -  $1\frac{1}{2}$  (main leaks) -  $\frac{1}{2}$  (bldg. leaks) = 3 comp.



SUBJECT ABA ELEC & HTG STUDY  
REPLACE AIR PIPING  
DESIGNER W. TODD  
CHECKER \_\_\_\_\_

AEP NO 694 1331 004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 7-1-96  
DATE \_\_\_\_\_

## ECO - C3 - B      Replace Compressed Air (CA) Piping

Since a detailed study of the CA piping was not in the Scope of Work, this analysis makes the following assumptions:

- 1) The CA pipe is 30% 4" and 70% 2" diameter.
- 2) The compressed air distribution system is the same length as the steam distribution system.
- 3) The new CA piping will utilize the existing supports and hangers.
- 4) The savings is based on reduced compressor operating time. See attached calculations.

$$\text{Savings} = \underline{5847.3 \text{ MBtu / YR}}$$

- 5) There is currently little or no maintenance on the existing system, so no O&M savings were considered for this ECO.

## ECO CALCULATIONS

Project: Replace Compressed Air Piping  
 Location: Pine Bluff Arsenal, AR  
 ECO No.: C3-B

RSH No.: 694-1331-004  
 Date: 7/2/96  
 Designer: W. Todd

### Assumptions:

1. Number compressors operating at full load during production: 5 (estimated by operating staff)
2. Number compressors operating at half load during production: 0 (estimated by operating staff)
3. Number compressors operating at full load during non-production: 2 (estimated by operating staff)
4. Number compressors operating at half load during non-production: 1 (estimated by operating staff)
5. Exist. compressors:
 

Design CA supply capacity:	825 cfm	(from nameplate data)
Calculated electric demand:	145.9 kW	(from nameplate data)
Measured electric demand:	130.7 kW	(measured during survey)
Actual percent motor load:	0.90	(measured kW / nameplate kW)
Demand per design supply cfm:	0.158 kW/cfm	(measured kW / design cfm)
6. New Compressors:
 

Design CA supply capacity:	825 cfm	(from nameplate data)
Electric demand at full load:	145.9 kW	(from nameplate data)
Estimated percent motor load:	0.90	(measured kW / nameplate kW)
Estimated electric demand:	130.7 kW	(measured during survey)
Demand per design supply cfm:	0.158 kW/cfm	(measured kW / design cfm)
7. Production schedule: 10 hr/day, 4 day/wk, 52 wks/yr
8. Compressed air distribution:
 

Process buildings (production) =	60%	(Assume 3.0 comp. / 5 comp)
Process buildings (non-prod) =	10%	(Assume 0.5 comp. / 5 comp)
Leaks at or in buildings =	10%	(Assume 0.5 comp. / 5 comp)
Leaks in main CA dist. piping =	30%	(Assume 1.5 comp. / 5 comp)
9. Average cost of electric energy consumed at PBA : \$16.79 /MBtu (calculated from electric bills)

### Estimate of compressed air supplied by the main system:

During Production = 5 comp. x 825 cfm/co. + 0 comp. x 412.5 cfm/co. = 4125 cfm

During Non-prod. = 2 comp. x 825 cfm/co. + 1 comp. x 412.5 cfm/co. = 2063 cfm

### Estimate of current energy consumption:

During Production = 0.158 kW/cfm x 4125 cfm = 651.8 kW

651.8 kW x 2080 hrs/year = 1355744 kWh/yr

1355744 kWh/yr x 0.003413 MB/kWh = 4627.2 MBtu/yr

During Non-prod. = 0.158 kW/cfm x 2063 cfm = 326.0 kW

326.0 kW x 6680 hrs/year = 2177680 kWh/yr

2177680 kWh/yr x 0.003413 MB/kWh = 7432.4 MBtu/yr

Total = 4627.2 MBtu/yr + 7432.4 MBtu/yr = 12059.6 MBtu/yr

E10-C3-B

Estimate of compressed air required at the buildings:

$$\begin{aligned}\text{During Production} &= 4125 \text{ cfm} \times 60\% + 4125 \text{ cfm} \times 10\% = 2888 \text{ cfm} \\ \text{During Non-prod.} &= 4125 \text{ cfm} \times 10\% + 4125 \text{ cfm} \times 10\% = 825 \text{ cfm}\end{aligned}$$

Estimate of energy consumption after ECO implementation:

$$\begin{aligned}\text{During Production} &= 0.158 \text{ kW/cfm} \times 2888 \text{ cfm} = 456.3 \text{ kW} \\ &456.3 \text{ kW} \times 2080 \text{ hrs/year} = 949104 \text{ kWh/yr} \\ &949104 \text{ kWh/yr} \times 0.003413 \text{ MB/kWh} = 3239.3 \text{ MBtu/yr} \\ \text{During Non-prod.} &= 0.158 \text{ kW/cfm} \times 825 \text{ cfm} = 130.4 \text{ kW} \\ &130.4 \text{ kW} \times 6680 \text{ hrs/year} = 871072 \text{ kWh/yr} \\ &871072 \text{ kWh/yr} \times 0.003413 \text{ MB/kWh} = 2973 \text{ MBtu/yr} \\ \text{Total} &= 3239.3 \text{ MBtu/yr} + 2973 \text{ MBtu/yr} = 6212.3 \text{ MBtu/yr}\end{aligned}$$

Estimate of annual energy and cost savings:

$$\begin{aligned}\text{Energy Savings} &= 12059.6 \text{ MBtu/yr} - 6212.3 \text{ MBtu/yr} = 5847.3 \text{ MBtu/yr} \\ \text{Cost Savings} &= 5847.3 \text{ MBtu/yr} \times \$16.79 / \text{MBtu} = \$98,176 / \text{Year}\end{aligned}$$



SUBJECT PBA ELEC EHTG STUDY  
COMPRESSED AIR PIPING  
DESIGNER W. TODD  
CHECKER \_\_\_\_\_

AEP NO 694-1331-004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 7-1-96  
DATE \_\_\_\_\_

ECO-C3-C

REPAIR COMPRESSED AIR PIPING

To be conservative it is assumed that all of the leaks are equivalent to about  $1/16$ " diameter. From Compressed Air Systems, the leakage rate at 100 psig is about 4 cfm.

$$\text{Total estimated leaks} = \frac{1237 \text{ cfm}}{4 \text{ cfm/leak}} = 309 \Rightarrow 300 \text{ leaks}$$

We did not observe this many leaks but feel this is a very conservative method of estimating the cost of repair.

Assume the leaks are distributed as follows:

100 valves, Remove and replace

100 fittings, remove and replace

100 pipe sections, remove and replace.

The energy savings are the same as that estimated for ECO-C3-B:

$$\text{Savings} = \underline{5847.3 \text{ MBtu / YR}}$$

## CONSTRUCTION COST ESTIMATE

Project: Repair Compressed Air Distribution Piping  
Location: Pine Bluff Arsenal, AR  
Basis: Schematic Design  
ECO Number: C3-C

RS&H No.: 694-1331-004  
Date: 7/1/96  
Estimator: W. Todd  
Filename: EST-C3C.XLS

ITEM DESCRIPTION	QUANTITY		MATERIAL/EQUIP		LABOR		TOTAL COST	SOURCE	
	No.	Unit	\$/Unit	Total	\$/Unit	Total		Material	Labor
Rental Leak Detector	1	Mo.	200	200		0	200	Vendor	
Survey CA piping for leaks	20	Day		0	600	12,000	12,000		Est. (1)
Replace Leaking Valves									
Remove existing valve	100			0	48	4,800	4,800		MMp191
Install new valve, 2", gate	100		252	25,200	48	4,800	30,000	MMp191	MMp191
Repair Leaking Piping									
Cut existing pipe section	100	Ea		0	15.15	1,515	1,515		Est. (2)
Pipe, 2", sch 40 steel	100	LF	4.82	482		0	482	MMp139	
Joint weld - equip & labor	200	Ea	3.29	658	27	5,400	6,058	MMp144	MMp144
Repair Leaking Fittings									
Cut existing fitting	100	Ea		0	15.15	1,515	1,515		Est. (2)
90 deg elbow, steel	100	LF	6.65	665		0	665	MMp158	
Joint weld - equip & labor	200	Ea	3.29	658	27	5,400	6,058	MMp144	MMp144
Personnal Hoist Rental	2	Mo.	1450	2,900		0	2,900	MMp15	
Subtotal Bare Costs				30,763		35,430	66,193		
Retrofit Cost Factors			0%	0	0%	0	0	MMp6	MMp6
Subtotal				30,763		35,430	66,193		
City Cost Index			0.952	(1,477)	0.632	(13,038)	(14,515)	MMp533	MMp533
Subtotal				29,286		22,392	51,678		
OH & Profit Markups			10%	2,929	53%	11,868	14,797	MMp7	MMp475
Subtotal				32,215		34,260	66,475		
State Sales Taxes			4.5%	1,450		N.A.	1,450	MMp476	
Subtotal				33,665		34,260	67,925		
Contingency			10%	3,367	10%	3,426	6,793	MEp6	MEp6
Total Construction Cost				37,032		37,686	\$74,718		
Design Fee				N.A.	6.0%	4,483	4,483		
SIOH				N.A.	6.0%	4,483	4,483		
Total Project Cost				37,032		46,652	\$83,684		

LEGEND:

Note (1)	Assumes 20 man-days to survey the comp air piping system.	\$550 /day + travel
Note (2)	Assumes 15 minutes per cut x 2 cuts at \$30.30 per hour (MMp475).	
MEp###	1996 Means Electrical Cost Data, page ###.	
MMp###	1996 Means Mechanical Cost Data, page ###.	
Vendor	Quote from GE Rentals, see attached information.	

A.5. C3-18

## AIR COMPRESSOR DATA

Survey by: GWF/WTT Date: 3/27/96  
 Maintenance Name: \_\_\_\_\_ Phone: \_\_\_\_\_  
 Building Number: 34-140 Compressor I.D. No.: 4  
 Service area or Loads: Area 3 Section 4 and Sections 1, 2 and 3 via header piping system.

## Compressor Specifications:

Mfg. & Model #: INGERSOLL-RAND TYPE XLE MODEL 16-10x7  
 Type: Recip.: ☒ Cent.: \_\_\_\_\_ Other: Date = 1967 SN: JH4868  
 Capacity (cfm): 825 Operating Pressure (psig): 130

## Electric Motor:

Type: Synchronous ☒ Induction: \_\_\_\_\_ Other: \_\_\_\_\_  
 Volts: 460 Amps: 206 Phases: 3 Hz: 60 RPM: 600  
 HP: 173 Mfg: GE Model No.: SSR684A60

Operation Schedule: hr/da: 24 da/wk: 7 mn/yr: 12

Cooling Method: Air: \_\_\_\_\_ Water: ☒

Air Source Location: Outdoors: ☒ Other: \_\_\_\_\_

Control System: Pneumatic staging control - 2 stages  
Manual on / OFF control.

Maintenance Schedule: as required, no PM

O&M log available: ☒ No Copies Obtained: ☒ No

Auxiliary Equipment: (Air Dryer, Heat Recovery, etc.)  
Air dryer disconnected.

Heat Recovery Potential: (Accessibility, heat load nearby) Use cooling water  
to preheat boiler feed water? ~ 250 AT

General Condition/Comments/Problems: AC Amps = 169  
PANEL DC AMPS = 34.5

## ELECTRIC MOTOR DATA SHEET

Survey Date: 3/27 & 1/30/96; Survey By: WTT / CSWEquipment ID/Function: Compressor No. 4Location: Bldg. 34 140

## Nameplate Data:

Manufacturer: General ElectricModel No.: 5SR 684 A60; Serial No.: DE 837 1527Insulation Class:    ; NEMA Design:    ; Code: A; Efficiency:    Horsepower 173; Frame 965Y; RPM 600; Service Factor    Volts 460; Amps 206; Phases 3; Hz 60; PF 0.8; kW    Type: Synchronous ✓; Induction    ; Other TYPE TSFor Synchronous Motors: DC Excitation Volts 125; Amps 33

## Electrical Measurements:

Measurements	← CSW →			← WTT →		
	Phase 1	Phase 2	Phase 3	Phase	Phase 1-2	Phase 2-3
Volts(rms)	478.6	415	483.1		511.1	502.6
Amps(rms)	176.6	191.0	195.1		168.8	185.5
kW	86.12	-0.38	51.58		89.95	36.61
kVAR	1.77 LE	0.65 LA	80.07 LE		2.73 LE	80.29 LE
kVA	86.16	0.76	95.27		90.02	88.27
Power Factor	0.99	-0.5	0.54		0.99	0.41
dPF	0.99	-0.5	0.54		0.99	0.41
kdVA	2.010	44.43	1.995		2.092	2.103

General Condition/Comments: Motor Control Panel Readings:169 Amps AC ; 34.5 Amps DC



## Compressed Air Systems by E. M. TALBOT

strainers should perform well for many years; however, they require periodic inspection and service.

### 4.3.5 Filter/Lubricators

The filter, regulator and lubricator are used to cleanse the air at the point of use, to regulate the pressure and thus the power or thrust of the tool or other pneumatic equipment, and finally, to lubricate that equipment, in that order. If the tool or other pneumatic equipment is not protected (by a filter) from serious contaminants, or if the equipment is not properly lubricated, it may wear more rapidly and thus may reduce efficiency and expend more air to accomplish the same job.

A clogged filter will have the effect of added pressure drop and a resulting loss of energy as explained previously. Only regular inspection and attention can keep these items in proper order.

The in-line lubricator is available in several designs. Different air users may require different types of lubricators. Manufacturers' tests have indicated that proper lubrication of air tools results in reduced air consumption for governed tools (up to 50% compared to dry tools) and increased speeds for ungoverned tools.

### 4.3.6 System Leakage

Of all of the maintenance failures, system leakage probably results in more lost compressed air energy than any other single factor. Plants have been observed where leakage losses are a modest 10% of the total compressed air capacity. Although this is "modest" by leakage standards, it is a significant annual dollar cost. Other plants have been observed with leakage rates in the range of 20% to 40% of total air usage. The cost of this leakage is high and avoidable.

The table below shows a conservative estimate of the annual cost of leaks of various sizes:

Equivalent Hole Diameter	Leakage Rate scfm	$10^3$ scf per year (4000 hrs)	Cost per year, \$ (@25¢/1000 cf)
1/64"	0.25	60	15
1/32"	0.99	238	59
1/16"	3.96	950	238
1/8 "	15.86	3806	952
1/4 "	63.44	15226	3806
3/8 "	142.74	34258	8564

Air at 100 psig

Orifice with sharp edges (Coefficient of flow = 0.61. Leakage and cost could be increased 60 percent for well rounded hole - coefficient = 0.97).

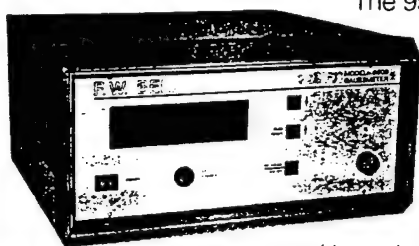
## Gaussmeters

### F.W. Bell

#### F.W. Bell 9200 Digital Gaussmeter

Microprocessor-based gaussmeter measures either ac or dc magnetic fields. 3.5-digit display has peak hold function and reads in either gauss or telsa. Six measurement ranges from 20 G to 20 kG. DC accuracy:  $\pm 0.5\%$ . Frequency response: dc to 5 kHz. Analog output of 2 volts full scale for recording. Built-in zero chamber. Autoranging. Includes axial and transverse probes. Rechargeable battery. Net weight: 8 lb.

#### F.W. Bell 9500 Digital Gaussmeter



The 9500 is a microprocessor-based, menu-driven gaussmeter with eight measurement ranges from 3 G to 30 kG. 3.75-digit LCD display

with analog bar-graph and peak hold. Measurement results can be displayed in either gauss or telsa. DC accuracy:  $\pm 0.25\%$ . Frequency response: dc to 5 kHz. Analog output: 3 volts full scale. Includes axial and transverse probes. Net weight: 19 lb.

### Holaday

#### Holaday HI-3604 ELF/Power Frequency Survey Meter

Measures electric and magnetic fields associated with 50/60 Hz power lines and electrically operated equipment. Frequency range: 30 to 1000 Hz. Magnetic field: 0.1 mG to 20 G in five ranges. Electrical field: 1 V/m (volt per meter) to 200 kV/m in five ranges. Features LCD display, bar-graph analog indicator for quickly locating maximum field strength and "hot spots", full autoranging, sealed membrane switch control panel, and data logging capability which allows saving up to 127 readings in internal memory. Net weight: 5 lb.

## Leak Detectors

### Biddle

Keith at X-7015

Rent for \$200/month

#### Biddle 569001 Leak and Corona Detector

Ultrasonic leak and corona detector for use with electrical corona sources and gas leaks. Visual and audible outputs indicate presence of ultrasonic signals from poor connections, faulty equipment or RF signal sources. Unit can detect a 0.002 in. leak at 5 ft. with only 10 psi of pressure. Frequency range: 35 to 45 kHz. Battery powered. Net weight: 6 lb.

### General Electric

#### General Electric H25 Ferret Halogen Leak Detector

Measures leaks down to 0.0005 oz/yr. Senses presence of halogen gas. Manual or automatic zero to background level. Complete with probe. Net weight: 17 lb.

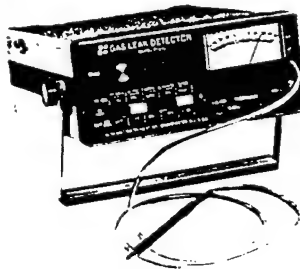
#### General Electric LS-20 Halogen Leak Standard

Standard used for calibrating halogen leak detectors. Must specify leak rate desired: 0 to 0.005/0.05/0.5/5.0/15.0 oz/yr. Net weight: 4 lb.

### Gow-Mac

#### Gow-Mac 21-250 Gas Leak Detector

Gas leak detector for helium, argon, carbon dioxide and refrigerants. Audible tone varies proportionally with meter deflection. Sensitivity:  $1 \times 10^{-5}$  cc/s (helium). Operates on 115 V/230 V, 50/60 Hz or internal rechargeable batteries. Net weight: 9 lb.



**If You Have A Particular Need, But Don't See  
The Equipment Listed Here, Call 1-800-GE-RENTS.**

A.S. C3-25

**1-800-GE-RENTS**

# EXHIBIT G COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

## COMPRESSED AIR

EQUIPMENT EFFECTIVENESS FACTOR %											
PINE BLUFF ARSENAL, ARKANSAS DEPARTMENT OF THE ARMY		BLDG USE									
BUILDING NUMBER		CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE				
31080	ELECTRONIC CALIBRATION FACILITY										
31100	MAINT FACILITY										
31150	PRODUCTION OFFICE										
31310	RAW MAT. WAREHOUSE										
31330	RAW MAT. WAREHOUSE										
31420	RAW MAT. WAREHOUSE										
31440	RAW MAT. WAREHOUSE										
31520	MIX BUILDING										
31530	FILL AND PRESS	200	120	200	120	200	120				
31531	OFFICE AND RESTROOMS										
31540	DOWNLOAD FACILITY										
31570	MUNITIONS STORAGE										
31620	PYRO MIX BLDG (THERMATE MIX)	200	120	200	120	200	120				
31630	FILL AND PRESS	1800	120	0	0	3000	120				
31631	BREAK AND RESTROOMS										
31640	ASSEMBLY	10	110	10	110	10	110				
31670	STORAGE										
31720	PYROTECHNIC PRODUCTION	10	120	10	120	10	10				
31730	STORAGE										
31820	STORAGE										
31830	AMMO QUAL FAC										
31860	STORAGE										
		2220		420		3420					
32000	CAFETERIA										
32030	INSPECTION GARAGE										
32035	ORDNANCE SHOP										
32070	IMPREG AND LAUNDRY	10	120	10	120	10	120				
32080	MHE BATTERY SHOP										
32090	WAREHOUSE										
32100	ELECTRONIC CALIBRATION FACILITY										
32130	AMMO QUAL FAC										
32150	AMMO QUAL FAC										
32230	FILTER BLDG	400	120	400	120	400	120				
32270	WAREHOUSE	1800	120	1800	120	1800	120				

A.5.C3-26

# EXHIBIT G COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

## COMPRESSED AIR

EQUIPMENT EFFECTIVENESS FACTOR %							
PINE BLUFF ARSENAL, ARKANSAS DEPARTMENT OF THE ARMY							
BUILDING NUMBER	BLDG USE	CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE
32310	RAW MAT. WAREHOUSE						
32330	RAW MAT. WAREHOUSE						
32420	RAW MAT. WAREHOUSE						
32440	EQUIPEMENT WAREHOUSE						
32510	PROD ENGR LAB						
32520	PROD ENGR LAB						
32530	FORMER BZ FACILITY						
32531							
32540	FORMER BZ FACILITY						
32550	AMMO QUAL FAC						
32570	OPERATIONS GENERAL PURPOSE						
32610	DRYING	100	120	100	120	100	120
32620	COLOR SMOKE MIX (GLATT)	178	120	356	120	356	120
32630	STORAGE						
32631	OFFICE AND RESTROOMS						
32640	PYROTECHNIC PRODUCTION	1200	120	0	0	1200	120
32670	SUU-7 TEST						
32720	PROD ENGR LAB						
32730	PROD ENGR LAB						
32820	MATERIAL STORAGE						
32830	MATERIAL STORAGE						
32860	STORAGE						
		3688		2666		3866	
33080	SAFETY EQUIP						
33100	CHANGE HOUSE						
33150	PRODUCTION						
33310	RAW MAT. WAREHOUSE						
33330	RAW MAT. WAREHOUSE						
33420	RAW MAT. WAREHOUSE						
33440	RAW MAT. WAREHOUSE						
33520	MIX BUILDING						
33530	FILL AND PRESS	2100	120	2100	120	2100	120
33531	PUBLIC TOILET						
33540	STORAGE						
33550	IN PROCESS STORAGE						

A.S.C. 27

# EXHIBIT G COMPRESSED AIR DEMAND FOR MOBILIZATION CONDITION

## COMPRESSED AIR

EQUIPMENT EFFECTIVENESS FACTOR %		PINE BLUFF ARSENAL, ARKANSAS DEPARTMENT OF THE ARMY				BLDG USE			
BUILDING NUMBER		CURRENT DEMAND COMPRESSED AIR PROCESS LOAD CFM	PRESSURE	PARTIAL BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE	BASELINE EMERGENCY PROCESS LOAD CFM	PRESSURE		
33570	LAP	0	0	0	0	0	0	0	0
33620	STARTER MIX BUILDING	10	120	10	120	10	120	10	120
33630	FILL AND PRESS	0	0	1800	120	1800	120	1800	120
33631	OFFICE AND RESTROOMS								
33640	ASSEMBLY BUILDING								
33650	IN PROCESS STORAGE								
33670	M116 LAP	600	120	600	120	600	120	600	120
33720	KC103 PROP								
33730	QC TEST FAC								
33820	STARTER MIX SLUGS								
33830	COMPONENT STORAGE								
33860	STORAGE IGLOO								
		2710		4510		4510		4510	
34110	WP FILLING	600	120	600	120	600	120	600	120
34120	AMMO QUAL FAC								
34130	WP UNLOAD TANKS								
34170	WP BULK STORAGE								
34350	ASSEMBLY AND PACKOUT								
34370									
34420									
34430	RAW MATERIAL WAREHOUSE								
34620									
34630	PYROTECHNIC PRODUCTION	120	130	120	130	120	130	120	130
34640	HC MIX	100	120	100	120	100	120	100	120
34650	START MIX SLEEVE								
34660	SUB ASSEMBLY								
34820	STORAGE								
34910	FE MAINTENANCE SHOP								
34970	ADMIN BUILDING								
		820		820		820		820	
42960	GRENADE TEST BUILDING								
44110	LAP	600	120	600	120	600	120	600	120

A.5.C3-28

PBA Compressor Operating Hours								6/17/96	
		32060		33060		34140		Total	Total
		No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	Comp.	Comp.
Day	Date	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	Op Hrs	% Hrs
Tuesday	1/16/96	20.00	0.00	24.00	0.00	0.00	10.00	54.00	38%
Wednesday	1/17/96	19.25	0.00	24.00	13.50	0.00	9.00	65.75	46%
Thursday	1/18/96	24.00	0.00	24.00	23.00	0.00	17.00	88.00	61%
Friday	1/19/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Saturday	1/20/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Sunday	1/21/96	24.00	0.00	24.00	0.00	0.00	24.00	72.00	50%
Monday	1/22/96	21.00	0.00	24.00	0.00	0.00	24.00	69.00	48%
Total Oper. Hours		156.25	0.00	168.00	36.50	0.00	132.00	492.75	
Total Available Hours		168	168	168	168	168	168	1008	
Percent Oper. Hours		93%	0%	100%	22%	0%	79%	49%	

## ENERGY PROJECT SUMMARY SHEET

<b>Installation and Location</b>	Pine Bluff Arsenal, Pine Bluff, Arkansas
<b>Project Title</b>	Replace Filtered Water Pump Motors
<b>Project Funding Category</b>	Federal Energy Management Program (FEMP)
<b>Total Investment</b>	\$9,000
<b>Annual Cost Savings</b>	\$1,200
<b>Savings-to-Invest. Ratio (SIR)</b>	2.09
<b>Simple Payback Period</b>	7.2 Years

### Contents

DD Form 1391, Front Sheet

Attachment 1 - Life Cycle Cost Analysis Summary

Attachment 2 - Description of Work to be Accomplished

Attachment 3 - Savings Calculations, Cost Estimate and Back-up Data

1. COMPONENT <b>ARMY</b>		FY 19__ MILITARY CONSTRUCTION PROJECT DATA			2. DATE September 6, 1996	
3. INSTALLATION AND LOCATION Pine Bluff Arsenal, Pine Bluff Arkansas				4. PROJECT TITLE Replace Filtered Water Pump Motors - FEMP		
5. PROGRAM ELEMENT		6. CATEGORY CODE		7. PROJECT NUMBER		8. PROJECT COST (\$000) \$9
9. COST ESTIMATES						
ITEM				U/M	QUANTITY	UNIT COST
COST (\$000)						
Remove four 30 HP motors. Install four new 30 HP premium efficient motors. Replace overload thermal units. See attached detailed estimate.						
Subtotal Construction Cost						\$6.8
Contingency (10%)						\$0.7
Total Construction Cost						\$7.5
Design Fee (6%)						\$0.4
SIOH (6%)						\$0.4
Total Cost						\$8.3
Total Requested (rounded)						\$9
10. DESCRIPTION OF PROPOSED CONSTRUCTION						
<p>The scope of work for this project consists of replacing all four of the existing filtered water pump motors with new energy efficient motors. The pumps are located in building 42-210 and are driven by 30 horsepower, standard efficient, electric induction motors. The existing motors will be removed and new premium efficient motors installed and connected to the existing electric circuits. The overload thermal units will be checked and replaced if necessary.</p>						



## ATTACHMENTS

1. Life Cycle Cost Analysis Summary
2. Description of Work to be Accomplished
3. Savings Calculations, Cost Estimate and Back-up Data

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 1**

**LIFE CYCLE COST ANALYSIS SUMMARY**

LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: ECO-E4

LCCID FY95 (92)

ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

INSTALLATION & LOCATION: P B ARSENAL REGION NOS. 6 CENSUS: 3

PROJECT NO. & TITLE: ECO-E4 EFFICIENT MOTORS FOR FILTERED WTR PUMPS

FISCAL YEAR 1997 DISCRETE PORTION NAME: COMPLETE PROJECT

ANALYSIS DATE: 07-01-96 ECONOMIC LIFE 20 YEARS PREPARED BY: W. TODD

1. INVESTMENT

A. CONSTRUCTION COST	\$	7429.	
B. SIOH	\$	446.	
C. DESIGN COST	\$	446.	
D. TOTAL COST (1A+1B+1C)	\$	8321.	
E. SALVAGE VALUE OF EXISTING EQUIPMENT	\$	0.	
F. PUBLIC UTILITY COMPANY REBATE	\$	0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)	\$		8321.

2. ENERGY SAVINGS (+) / COST (-)

DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

FUEL	UNIT COST \$/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL \$ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	\$ 16.79	69.	\$ 1155.	15.08	\$ 17420.
B. DIST	\$ .00	0.	\$ 0.	18.57	\$ 0.
C. RESID	\$ .00	0.	\$ 0.	21.02	\$ 0.
D. NAT G	\$ 2.81	0.	\$ 0.	18.58	\$ 0.
E. COAL	\$ .00	0.	\$ 0.	16.83	\$ 0.
F. PPG	\$ .00	0.	\$ 0.	17.38	\$ 0.
M. DEMAND SAVINGS			\$ 0.	14.88	\$ 0.
N. TOTAL		69.	\$ 1155.		\$ 17420.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		\$	0.
(1) DISCOUNT FACTOR (TABLE A)		14.88	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		\$	0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTOR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	\$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)\$ 0.

4. FIRST YEAR DOLLAR SAVINGS  $2N3+3A+(3Bd1/(YRS \text{ ECONOMIC LIFE}))$ \$ 1155.

5. SIMPLE PAYBACK PERIOD (1G/4) 7.20 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) \$ 17420.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.09  
(IF < 1 PROJECT DOES NOT QUALIFY)

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 2**

**DESCRIPTION OF WORK TO BE ACCOMPLISHED**

## **ECO-E4**

**Replace the filtered water pump motors in Building 42-210 with energy efficient motors.**

### **Description**

There are four filtered water pumps that pump the stored ground water from the holding tank through filters and chlorinators and then to the high tanks for distribution to the Arsenal. The pumps are driven by 30 horsepower electric induction motors. This project consists of replacing all four of the existing filtered water pump motors with new energy efficient motors.

The four filtered water pump motors are located in Building 42-210. The pumps are operated on an alternating schedule that has two of them running during any given day. A typical schedule for nine days is to run pumps 1 and 2 one day, then 1 and 3 the next day, 1 and 4, 2 and 3, 2 and 4, 2 and 1, 3 and 4, 3 and 1, 3 and 2 and back to pumps 1 and 2 on the tenth day. The pump logs indicate these pumps operated for a total of about 9170 hours during calendar year 1995. The annual operating hours represent an average of approximately 2290 hours per year per motor.

The PBA DPW staff indicated they plan to replace the existing filtered water pumping system including the four pumps, motors and some of the piping. The new pumping system will utilize two larger pumps and motors.

The existing motors are old and have an estimated efficiency of 88 percent. New 30 horsepower premium efficiency motors have an efficiency of about 94 percent. Field measurements of motor kW indicate these motors are operating at approximately 90 percent of full load.

Due to the pending replacement of the filtered water pumping system, the payback for replacing the existing motors may be longer than the motors will be utilized. Therefore, this ECO is recommended only if the new pumping system will not be installed before the end of the 7.2 year payback period.

**PROGRAMMING DOCUMENTATION - FEMP**

**ATTACHMENT 3**

**SAVINGS CALCULATIONS, COST ESTIMATE AND BACK-UP DATA**



SUBJECT PBA ELEC + HTG STUDY  
EFF. FILTERED WTR PUMP MOTORS  
DESIGNER W. TODD  
CHECKER \_\_\_\_\_

AEP NO 694-1331-004  
SHEET \_\_\_\_\_ OF \_\_\_\_\_  
DATE 6-20-96  
DATE \_\_\_\_\_

## ECO-E4 ENERGY EFFICIENT MOTORS FOR FILTERED WATER PUMPS

There are 4 filtered water pump in Bldg. 42-210. They are used to pump treated water from the water plant up to the water towers. Two of the pumps are used at one time and they are all alternated into service on a daily schedule: day 1 - pumps 1+2, day 2 - pumps 1 and 3, day 3 - pumps 1 and 4, day 4 pumps 2 and 3, etc.

Actual operating hours were obtained from the water plant staff. See attached message from G. Burris, and calculation of annual operating hours.

The motor operating kw was measured and the average kw was used in the energy savings calculations. See attached Electric Motor Data Sheets.

$$\text{AVG KW} = (26.4 + 22.1 + 23.6 + 22.4) \text{ kw} \div 4 = 23.6 \text{ KW}$$

The existing motors are very old; the efficiency was estimated based on a C/s Engineer article (see attached) to be ~ 88%

Energy savings for one motor was calculated by the attached spreadsheet.

$$\text{Total Energy Savings} = 17.2 \times 4 = \underline{68.8 \text{ MBtu/YR}}$$

## CONSTRUCTION COST ESTIMATE

Project: Energy Efficient Motors - Filtered Water Pumps  
Location: Pine Bluff Arsenal, AR  
Basis: Schematic Design  
ECO Number: E4

RS&H No.: 694-1331-004  
Date: 6/21/96  
Estimator: W. Todd  
Filename: EST-E4.XLS

[illegible]

**LEGEND:**

Note (1)	Assumes 10 minutes to install each thermal unit.
GRp###	Grainger General catalog Number 386, page ###.
MEp###	1996 Means Electrical Cost Data, page ###.
MMp###	1996 Means Mechanical Cost Data, page ###.
SDp###	Square-D Digest Number 170, page ###.

A.5.E4-4



# ECO CALCULATIONS Energy Efficient Motors

Project: Filtered Water Pumps - Bldg. 42-210  
Location: Pine Bluff Arsenal, AR  
ECO No.: E4

RSH No.: 6941331004  
Date: 6/20/96  
Designer: W. Todd

- Assumptions:
- (1) Motor nameplate horsepower = 30 (Name plate data)
  - (2) Efficiency of existing motor = 88% (C/S Engineer Article)
  - (3) Exist. motor electric data: 440 V (Name plate data)  
36 A "  
3 ph "  
0.84 pf (Estimated)
  - (4) Measured/estimated kW = 23.6 (Avg. of measurements)
  - (5) Avg. annual operating hours = 2293 (Operating logs)
  - (6) New motor premium efficiency = 94% (Grainger No. 386)

$$\text{Max kW of existing motor} = \frac{440 \text{ V} \times 36 \text{ A} \times 1.73 \times 0.84}{0.88 \times 1000} = 26.2 \text{ kW}$$

$$\text{Percent operating load} = \frac{23.6 \text{ kW}}{26.2 \text{ kW}} = 90.1\%$$

$$\text{Operating kW of new motor} = \frac{30 \text{ hp} \times 0.901 \times 0.7457 \text{ kW/bhp}}{0.94} = 21.4 \text{ kW}$$

$$\text{Electric Demand Savings} = 23.6 \text{ kW} - 21.4 \text{ kW} = 2.2 \text{ kW}$$

$$\text{Electric Energy Savings} = 2.2 \text{ kW} \times 2293 \text{ Hr/Yr} = 5,045 \text{ kWh/Yr}$$

$$\text{Electric Energy Savings} = 5,045 \text{ kWh/Yr} \times 0.003413 \frac{\text{MBtu}}{\text{kWh}} = 17.2 \text{ MBtu/Yr}$$

Pine Bluff Arsenal - Electrical Demand and Heating Study  
 Building 42-210, Filtered Water Pumps  
 Date: 6/20/96

ASSUMPTIONS:

- 1) Operating schedule obtained from PBA staff, see attached.
- 2) Two pumps operate and the other two are standby.

Mon-YR	Total Op. Hr/Da (1)	Available Hr/Da (2)	Diversity (1) / (2)	Number Days/Mo	Total Hrs/Mo (1) x Day/Mo
Jan-95	26.3	96	0.27	31	815
Feb-95	27.0	96	0.28	28	756
Mar-95	25.3	96	0.26	31	784
Apr-95	25.3	96	0.26	30	759
May-95	24.5	96	0.26	31	760
Jun-95	25.8	96	0.27	30	773
Jul-95	25.0	96	0.26	31	775
Aug-95	24.0	96	0.25	31	744
Sep-95	22.8	96	0.24	30	684
Oct-95	23.7	96	0.25	31	735
Nov-95	26.3	96	0.27	30	788
Dec-95	25.8	96	0.27	31	800

Total annual operating hours = 9172

Average annual operating hours per pump motor = 2293

MESSAGE DISPLAY FOR NANCY RIMMER

CC NANCY RIMMER  
GREGORY BURRIS

From: GREGORY BURRIS Host: MVB  
Postmark: Feb 05,96 12:47 PM Delivered: Feb 05,96 12:47 PM  
Status: Certified Previously read  
Subject: RAW WATER HOURS PER DAY FILTERED WATER HOURS PER.DAY

-----  
Message:

JAN.95	9.00 HRS.	26.30 HRS.	PER TWO PUMPS
FEB.95	8.75	27.00	
MAR.95	9.75	25.30	
APR.95	9.40	25.30	
MAY 95	9.50	24.50	
JUN.95	9.60	25.75	
JULY.95	9.75	25.00	
AUG.95	9.75	24.00	
SEPT.95	9.75	22.80	
OCT.95	9.60	23.70	
NOV.95	10.90	26.25	
DEC.95	10.30	25.80	

-----X-----

A.5. E4-7

By DARRYL J. VAN SON  
Baldor  
Fort Smith, Ark.

Last year, the World Watch Institute in Washington, D.C., released a study called "Building on Success: The Age of Energy Efficiency." It gives an overview of the long-term implications of energy use and waste. The authors say an environmentally sound energy strategy is a prerequisite to a sustainable society and that a prerequisite to any viable strategy is more efficient energy use.

The good news in this report is how much we have accomplished collectively in the last 15 years. Since the Arab oil embargo of 1973, the world has saved far more energy through improved efficiency than it has gained from all new sources. The United States reduced energy intensity by more than 20%. From 1973 to 1987, our GNP went up 40% but total energy use grew by only 3%. This vast improvement has occurred largely without notice. The World Watch authors state, "We feel it is now possible in most industrialized countries to keep energy consumption level for the foreseeable future without sacrificing economic growth."

Part of the reason we did not notice these improvements was that there was no single sweeping technological breakthrough or new "wonder" source discovery. It was accomplished and will continue to be accomplished through a myriad of small incremental improvements in everything we design and build. The United States now spends 11.2% of its GNP on energy, but as much as 50% of this is wasted on inefficiencies of one form or another. There is much room for improvement in the future.

Between 50% and 60% of U.S. electricity is used to drive electric motors. Therefore, they are an obvious target for careful specifying. Of this electricity, more than 80% drives integral horsepower, polyphase motors. Although fractional horsepower motors represent the highest unit volume, they consume only 7% of the electricity used.

#### Motor efficiency

To look at reducing motor energy use, it is best to investigate two areas: the motor's efficiency and the operating system efficiency. In the last 10 years, virtually every motor manufacturer has introduced a line of premium-efficiency motors. This technology also filtered down to standard motors. In other words, the

motor industry has continued to improve products across the board (see Figure 1).

The U.S. Department of Energy studied motor efficiency and published the "Classification and Evaluation of Electric Motors and Pumps" in February 1980. Comparing "Average Standard Motors" of the late

**Between 50% and 60%  
of U.S. electricity  
is used to drive  
electric motors**

1970s to today's nonpremium motors shows that even "normal" motors have reduced wasted energy by more than 11% on average. For example, a 75-hp, four-pole motor in 1979 had a typical efficiency of 90.8%. In 1989, that same motor typically has a 92.1% efficiency. That same rating in a premium motor will, on average, be 94.3% efficient.

Many manufacturers offer products with labels such as high efficiency, premium efficiency, super efficient and extra efficient. However, of greater importance is the actual efficiency on the nameplate. Domestic manufacturers have now standard-

ized on IEEE 112B test methods, so direct comparison of nameplates is practical. Most motor manufacturers have some form of computerized savings and payback analysis. However, a quick approximation of annual savings can be calculated with this formula:

$$\text{Annual Savings} = \text{Efficiency difference} \times \text{kw} \times \$/\text{kwh} \times \text{hrs/yr} \times 1.15$$

Where:

Efficiency difference = Motor A - Motor B (decimal, not percent)

kw = hp  $\times$  .746

\$/kwh = local power rate

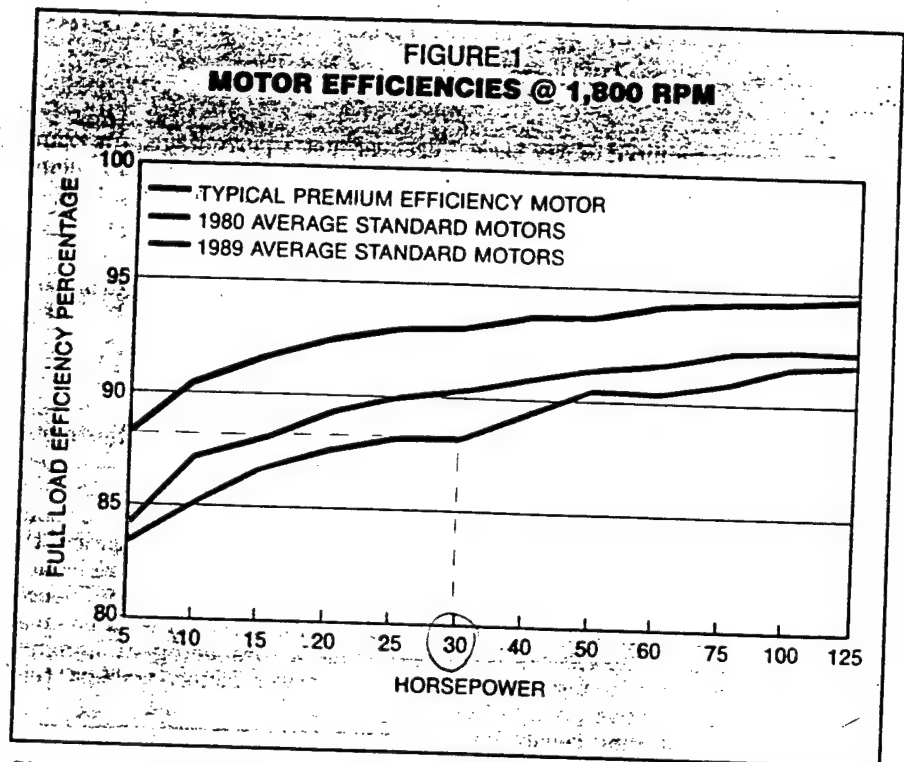
hrs/yr = hours/day  $\times$  days/year

Example: 75 hp, 94.3% efficiency vs. 90.8% efficiency, continuous duty at 6 cents per kwh:  $0.035 \times 55.95 \times 0.06 \times 8736 \times 1.15 = \$1,180$  annual savings.

This boils down to greater savings. The more the motor is used, the higher the energy cost, the higher the horsepower or the greater the efficiency improvement.

As a rule-of-thumb, premium-efficiency motors are the best choice if power rates are more than 6 cents per kilowatt-hour and the motor is used two shifts per day or more.

The next logical step is payback analysis. This is a simple calculation of annual savings divided by the premium price differential greater than a standard motor. This yields the



Since the late 1970s, average efficiencies for standard motors have improved significantly.

# ELECTRIC MOTOR DATA SHEET

Survey Date: 1/21 & 3/27/96; Survey By: CSW / WTT  
 Equipment ID/Function: Filtered Watered Pump No. 1  
 Location: Building 42-210

## Nameplate Data:

Manufacturer: Sterling Motor  
 Model No.: TYPE KF; Serial No.: 145090  
 Insulation Class:    ; NEMA Design:    ; Code:    ; Efficiency:      
 Horsepower 30; Frame 405; RPM 1800; Service Factor      
 Volts 220/440; Amps 72/36; Phases 3; Hz 60; PF    ; kW      
 Type: Synchronous    ; Induction ✓; Other 40°C Rating  
 For Synchronous Motors: DC Excitation Volts    ; Amps    

## Electrical Measurements:

Measurements	Phase	Phase	Phase	<del>Phase</del> TOTAL	Phase	Phase
Volts(rms)	281.7	277.3	283.2			
Amps(rms)	36.37	34.05	35.5			
kW	9.217	8.399	8.781	26.4		
KVAR	LA 4.501	LA 4.247	LA 4.926			
kVA	10.25	9.413	10.07			
Power Factor	0.89	0.89	0.87			
dPF	"	"	"			
kdVA	174.7	137.6	158.9			

General Condition/Comments:

# ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW

Equipment ID/Function: Filtered Water Pump No. 2

Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: \_\_\_\_\_

Model No.: \_\_\_\_\_; Serial No.: \_\_\_\_\_

Insulation Class: \_\_\_\_\_; NEMA Design: \_\_\_\_\_; Code: \_\_\_\_\_; Efficiency: \_\_\_\_\_

Horsepower 30; Frame \_\_\_\_\_; RPM \_\_\_\_\_; Service Factor \_\_\_\_\_

Volts \_\_\_\_\_; Amps \_\_\_\_\_; Phases \_\_\_\_\_; Hz \_\_\_\_\_; PF \_\_\_\_\_; kW \_\_\_\_\_

Type: Synchronous \_\_\_\_\_; Induction \_\_\_\_\_; Other \_\_\_\_\_

For Synchronous Motors: DC Excitation Volts \_\_\_\_\_; Amps \_\_\_\_\_

## Electrical Measurements:

Measurements	Phase	Phase	Phase	<del>Phase</del> TOTAL	Phase	Phase
Volts(rms)	282.0	278.0	284.9			
Amps(rms)	31.37	29.54	30.55			
kW	7.673	7.109	7.343	22.1		
kVAR	4.415 LAG	4.091 LAG	4.092 LAG			
kVA	8.854	8.204	8.716			
Power Factor	0.86	0.86	0.84			
dPF	"	"	"			
kdVA	152.2	138.7	146.9			

General Condition/Comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW

Equipment ID/Function: Filtered Water Pump No. 2

Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: \_\_\_\_\_

Model No.: \_\_\_\_\_; Serial No.: \_\_\_\_\_

Insulation Class: \_\_\_\_\_; NEMA Design: \_\_\_\_\_; Code: \_\_\_\_\_; Efficiency: \_\_\_\_\_

Horsepower 30; Frame \_\_\_\_\_; RPM \_\_\_\_\_; Service Factor \_\_\_\_\_

Volts 220/440; Amps \_\_\_\_\_; Phases 3; Hz \_\_\_\_\_; PF \_\_\_\_\_; kW \_\_\_\_\_

Type: Synchronous \_\_\_\_\_; Induction \_\_\_\_\_; Other \_\_\_\_\_

For Synchronous Motors: DC Excitation Volts \_\_\_\_\_; Amps \_\_\_\_\_

## Electrical Measurements:

Measurements	Phase	Phase	Phase	<del>Phase</del> TOTAL	Phase	Phase
Volts(rms)	282.2	278.4	284.7			
Amps(rms)	34.22	31.29	32.83			
kW	8.350	7.495	7.715	23.6		
kVAR	4.874 LAG	4.452 LAG	5.323 LAG			
kVA	9.670	8.719	9.375			
Power Factor	0.86	0.85	0.82			
dPF	"	"	"			
kdVA	183.3	154.8	136.1			

General Condition/Comments: Pump Data: 700 GPM, 130 ft HD

Gardner-Denver, Cent. Pump, Quincy, Ill.

Size 5, TYPE F, SN 261495, 1750 RPM

A.5.E4-11

# ELECTRIC MOTOR DATA SHEET

Survey Date: 1/31/96; Survey By: CSW  
 Equipment ID/Function: Filtered Water Pump No. 4  
 Location: Bldg. 42-210

Nameplate Data: Not Legible

Manufacturer: \_\_\_\_\_

Model No.: \_\_\_\_\_; Serial No.: \_\_\_\_\_

Insulation Class: \_\_\_\_\_; NEMA Design: \_\_\_\_\_; Code: \_\_\_\_\_; Efficiency: \_\_\_\_\_

Horsepower \_\_\_\_\_; Frame \_\_\_\_\_; RPM \_\_\_\_\_; Service Factor \_\_\_\_\_

Volts \_\_\_\_\_; Amps \_\_\_\_\_; Phases \_\_\_\_\_; Hz \_\_\_\_\_; PF \_\_\_\_\_; kW \_\_\_\_\_

Type: Synchronous \_\_\_\_\_; Induction \_\_\_\_\_; Other \_\_\_\_\_

For Synchronous Motors: DC Excitation Volts \_\_\_\_\_; Amps \_\_\_\_\_

## Electrical Measurements:

Measurements	Phase	Phase	Phase	<del>Phase</del> TOTAL	Phase	Phase
Volts(rms)	281.9	277.4	283.1			
Amps(rms)	32.73	29.67	31.06			
kW	8.015	7.110	7.301	22.4		
kVAR	4.577 LAG	4.192 LAG	4.898 LAG			
kVA	9.232	8.255	8.793			
Power Factor	0.86	0.86	0.83			
dPF	"	"	"			
kdVA	187.5	142.4	153.4			

General Condition/Comments: \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_